

# 1996

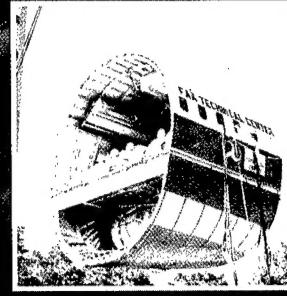
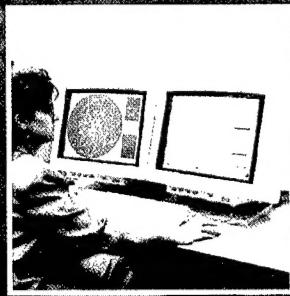
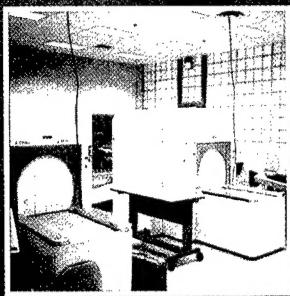
## Federal Aviation Administration Plan for Research, Engineering, & Development



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May 1996

Report of the Federal Aviation Administration  
to the United States Congress pursuant to  
49 United States Code 44501(c).



U.S. Department of Transportation  
Federal Aviation Administration

**Cover:** Federal Aviation Administration Test of the Pavement Arresting System

**Front Inserts (counterclockwise):**

- Civil Aeromedical Institute laboratory workstation used to develop and evaluate models of team coordination and communication.
- General aviation data link system installed in a Beech A-36 Bonanza.
- Civil Aeromedical Institute scientists evaluate medical information gleaned from aircraft accidents to improve the safe operation of aircraft.
- Drop test to measure impact to passengers and interior fixtures.
- Doppler Radar display.
- Laboratory workstation developed at the Civil Aeromedical Institute to recreate air traffic control operational errors and incidents.
- InVision CTX-5000 explosive detection system.

**Back Insert:** Technician installing noise monitoring equipment.

*Photos courtesy of FAA Technical Center, Civil Aeromedical Institute, FAA Data Link Program, and FAA Public Affairs Office.*

1996

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**Federal Aviation Administration  
Plan for Research, Engineering,  
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## 1.0 OVERVIEW

### 1.1 Introduction to the Research, Engineering and Development (R,E&D) Program

The Federal Aviation Administration (FAA) manages and operates the National Airspace System (NAS), a significant national resource. The demands on this system are continuously growing, and changing technologies provide the opportunity to improve system effectiveness and efficiency. Today, 22 of the country's largest airports experience more than 20,000 hours of delay per year, and the number of major airports with more than 20,000 hours of delay is projected to grow to 33 by 2003. With an average aircraft operating cost of approximately \$1,600 per hour of delay, airlines operating at each of these airports currently incur at least \$32 million in annual delay costs.

Aviation and related industries are also challenged by factors including energy and the environment. While fuel costs have consistently decreased during recent years, they still represent an appreciable percentage of operating cost. In 1993 fuel and oil accounted for about 12 percent of total operating expense for the major airlines. While reducing fuel usage is a priority in terms of energy conservation, it is also an increasingly critical environmental issue, based on recent findings relating to nitrogen oxide emissions at high altitudes. Given the projected increases in aviation activity and stringent environmental standards being proposed in Europe and else-

where, noise and engine emissions reductions are essential to the national aviation industry's viability.

The FAA must accommodate the increasing demand on limited airport and airspace capacity, deal with crucial airport security issues, and address safety concerns through all phases of flight to ensure that the NAS continues to be the world's safest airspace. These requirements pose unprecedented challenges, which can only be met through a major investment in R,E&D.

The projects in this Plan are those needed to bring the FAA's vision of the future system to reality in the context of a continuing top-level system engineering process. The Plan has received contributions from across the spectrum of scientific, operational, and user communities. These contributions from both inside and outside government are always welcome, provide valuable inputs, and are greatly appreciated. The 1996 R,E&D Plan, containing projects active in calendar year 1996, is a 15-year planning document. Projects within the R,E&D Plan have been grouped into nine thrust areas. These thrust areas offer a logical grouping of related projects based on common attributes. The R,E&D milestones included in this Plan are based on projected funding levels during the 15-year planning period.

#### Cooperative Research With NASA and DOD

The FAA, in an effort to ensure maximum leveraging of research funds and to eliminate duplicative activities, cooperates extensively with both the National Aeronautics and Space Administration and the Department of Defense.

In November 1993, the President established the National Science and Technology Council (NSTC) to assess federal research and development priorities and to better integrate research and development efforts across agencies. An

NSTC committee on transportation published the report, Goals for a National Partnership in Aeronautics Research and Technology, focusing on needs and benefits associated with federal research and development investments in aeronautics and aviation. In response to this report, an Aeronautics and Aviation Subcommittee, chaired jointly by the FAA Associate Administrator for Research and Acquisitions, the NASA Associate Administrator for Aeronautics, and the DOD Director of Advanced Technology, was formed to develop a strategic view of federal research and development investments. The subcommittee's report will be used by the Office of Management and Budget to review future budget submissions to ensure coordination among the three organizations.

Formal coordination between the FAA and NASA has been an ongoing activity through the FAA/NASA Coordinating Committee. The committee is jointly chaired by the FAA Associate Administrator for Research and Acquisitions and the NASA Associate Administrator for Aeronautics. The committee established formal memoranda of understanding defining broad research areas of mutual interest in human factors, airworthiness, severe weather, environmental compatibility, and integration of cockpit and air traffic control operations.

### **Research, Engineering, and Development Budgeting Process**

During the initial stage of the 1997 R,E&D budget process, research proposals were submitted by sponsor organizations. To review and prioritize these research proposals, teams comprised of sponsors, system engineers, operational research personnel, and program managers were formed for each of the ten R,E&D budget/thrust areas. This prioritization was based on the criticality of project contributions toward eliminating shortfalls that affect FAA strategic goals. Congressional issues, concerns of the aviation community as a whole, as well as cost effectiveness and long- and short-term benefits were also considered as prioritization factors. After prioritization within chapters/thrust areas, an assessment team worked

In 1995, the FAA and NASA signed a memorandum of understanding that initiates joint research and development activities to develop, validate, and implement airspace system user operational flexibility and productivity improvements. The initiative will be managed by a FAA/NASA Integrated Product Team. The team will address both near- and long-term requirements, with initial emphasis on improvements that can be implemented within the next ten years.

Cooperative interagency research agreements between the FAA and DOD span a broad spectrum of research areas including: Security – detecting explosives in carry-on and checked baggage and cargo; Safety – nondestructive inspection techniques); and Human Factors – situational awareness and decisionmaking processes for controllers and aircrews and research in flight crew fatigue and other physiological factors affecting performance and efficiency.

In the future, the FAA will continue to investigate avenues for leveraging scarce research resources through additional partnerships with other government agencies, industry, and foreign aviation research and development organizations.

across chapter boundaries to develop an integrated R,E&D program. Based on the prioritization process and budget realities, funds were reapportioned by chapter across the integrated R,E&D program.

The FAA is further refining its process for developing the R,E&D budget and its R,E&D project portfolio through a more extensive evaluation process. In developing the FY 1998 budget, each individual project will be evaluated on elements determined to be important to the FAA's mission. These elements include: benefits for airspace users; contribution to the FAA Strategic Plan goals and objectives; consistency with the NAS

architecture; technological relevance to the FAA's mission; risk; and consistency with F&E planning. This process will help identify the

projects' relative investment priority and will position the FAA to meet its future mission requirements more cost-effectively.

### **Relationship With NAS Architecture**

The NAS architecture is intended to provide a comprehensive plan for an affordable, evolutionary modernization of the National Airspace System that will deliver incremental benefits to both NAS users and service providers. The first version of the NAS architecture, Version 1.0 sets forth the basic concepts and principles of the NAS architecture and establishes the direction and method for the architecture's further development. As this development continues, the architecture will rapidly bring benefit to the process of infrastructure investment by providing analytically defensible rationale for investment decisions. When the architecture is mature, it

will be the principal framework of NAS infrastructure investment decisions. This rationale will include criteria for selection of R,E&D programs that exploit technologies and techniques compatible with validated architectural alternatives.

Far-term and mid-term architecture alternatives are likely to require applications of technology that are not yet well understood. The FAA will conduct analyses to understand application risks, benefits, and costs of new technology. New R,E&D capabilities will be developed where needs are identified.

### **Relationship With Strategic Planning**

FAA Strategic Plan goals and objectives are supported by projects in this Plan. Table 2 in Section

1.3 lists R,E&D projects keyed to the applicable 1995 Strategic Plan goals and objectives.

## **1.2 FAA Services**

R,E&D projects contribute vital inputs to FAA services provided to the flying public. These service areas include: aircraft and aircrew, flight service stations, airport, terminal, and en route. Some projects provide inputs to R,E&D-specific services. These R,E&D-specific services provide the research infrastructure necessary to con-

duct experiments, test theories, concepts, and other technologies in support of other R,E&D projects.

The following narratives describe the FAA service areas in further detail.

### **Aircraft and Aircrew**

The aircraft and aircrew service area covers safety and regulatory activities for both humans and machines. Aviation safety services encompass the FAA's responsibility for aircraft and equipment certification, flight operations oversight, and maintenance oversight provided for both private and commercial operations. To accomplish its oversight responsibilities, the FAA sets policy and develops standards that re-

sult in operational procedures, which are then monitored periodically.

An important safety service provided by the FAA through the Office of Accident Investigation is to help determine causes of accidents and disseminate safety information to prevent future accidents. The office maintains an independent investigation capability that enables the FAA to take corrective action.

As the FAA's focal point for accident investigations, the office also assists the National Transportation Safety Board in collecting and analyzing accident data to determine probable cause. A key element of the entire investigation service is sharing accident and safety information with the aviation industry, foreign governments, and the military.

The Office of Aviation Medicine provides services to the flying public by applying medical knowledge to aviation safety. While the aviation personnel medical qualification service has many facets, the principal service is to ensure that pilots and controllers are medically able to perform their jobs. Airmen and air traffic controllers must meet medical standards established by the FAA. These standards are applied through a network of private physicians for non-FAA pilots and controllers, and either private physicians or FAA clinics for FAA employees. The physicians conducting the examinations are trained in aerospace medicine by the FAA.

An in-house aeromedical and human factors research capability provides useful information to the aviation industry in the form of technical

reports, research procedures and protocols, and forensic support to the National Transportation Safety Board for accident investigations. Aeromedical analyses and research services are the FAA's focal point for information and knowledge about aerospace medicine

The aircraft and equipment certification service ensures that aircraft and equipment are airworthy and that they meet safety requirements. Inspectors follow a new aircraft or equipment design from inception to factory roll out. This service is provided to a wide range of aviation products, from experimental kit-built aircraft to the most sophisticated commercial products, including foreign-made aircraft and equipment that will operate in United States airspace.

Developing flight procedures for airways, instrument approaches, and instrument departures is another major service. These procedures permit aircrews to operate safely under instrument flight rules when weather conditions prevent visual flight operations. Added benefits derived from these procedures include noise abatement and expeditious movement of aircraft within the NAS.

## Flight Service

This service area encompasses the pre-flight and inflight services provided primarily to general aviation by flight service stations. Pre-flight services include briefings and assistance in filing flight plans. These briefings provide all necessary meteorological and aeronautical information. Meteorological information contains current and forecast weather along the intended route of flight. Aeronautical information includes notices to airmen, special military operations, and preferred routes of flight.

Inflight services parallel those provided in pre-flight, except the information is time-critical. Inflight services also include receiving and dis-

seminating pilot reports of weather and other hazards encountered inflight. Airport information is provided to landing and departing aircraft at non-towered airports or at airports where the tower is closed. Civil and military flight movement messages, such as military stopovers, flight plan cancellations, and route changes, are received and disseminated. Emergency services are provided to aircraft in distress by evaluating the nature of the emergency and determining the most appropriate course of action. Arrivals of aircraft on flight plans are monitored, and search and rescue procedures may be initiated for overdue aircraft.

## Airport

The airport service area includes all activities within a four nautical mile radius of the airport, and it involves engine startup through takeoff and also landing to engine shutdown. The FAA, existing as an airport tenant, typically provides air traffic control, airway facilities, and security services. The airport traffic control tower provides services on the ground and in the air within approximately four nautical miles of the airport. Basic airport traffic control services include clearance delivery, ground control, and local control. Clearance delivery relays flight plan information to inform the pilot about the route of flight. Ground control provides taxi instructions for aircraft and controls vehicles on the airport movement area, resulting in safe and efficient traffic flow. Local control provides landing and takeoff clearances for aircraft arriving and/or departing, as well as separation for airborne aircraft in the immediate airport area. An important function in local control is providing special weather notices such as windshear or microburst alerts. An additional service provided by the control tower is the automated terminal information service (ATIS) that transmits airport information such as active runways, winds, altimeter settings,

or other special airport information. ATIS is a recorded message broadcast on a discrete frequency to minimize repetitious communications.

Airway Facilities personnel install, operate, and maintain facilities and equipment integral to the air traffic system at airports. Typical airport equipment includes landing and navigation aids, radars, communication networks, and automation equipment. This equipment provides pilots and controllers with the information needed to conduct air traffic operations. Additionally, the FAA is responsible for supporting improvements in the pavement technology area, particularly in response to the development of larger aircraft.

The FAA has oversight responsibility for ensuring security at all airports under its jurisdiction and maintains security offices at selected major airports. Examples of the FAA's security responsibility include airport perimeter fencing, passenger and baggage screening including advanced detection techniques; and aircraft ramp access control. These services are performed in conjunction with airport operators.

## Terminal

The terminal service area is a geographic area containing one or more airports and a terminal radar approach control (TRACON) representing the transition from selected metropolitan airports to the en route environment. Airport traffic control towers, while located on an airport and providing services at an airport, control air traffic within the terminal airspace.

The terminal radar approach control facility provides services between airports and the en route environment. These services accommodate aircraft operating under both instrument flight rules and visual flight rules. Terminal radar approach control facilities can be collocated on an airport

with the airport traffic control tower or operated as a stand-alone facility. The primary services provided are separation, sequencing, traffic advisories, traffic alerts, significant weather advisories, and radar vectoring for arriving, departing, and through traffic.

The separation service maintains the horizontal and vertical distances between aircraft. Sequencing works in conjunction with separation to establish the order in which aircraft will land and depart. Traffic advisories inform crews of the proximity of other aircraft in relation to their aircraft. Traffic alerts are priority messages issued by air traffic controllers to aircraft when flight

safety may be compromised. Significant weather advisories inform aircrews when a weather phenomena, such as windshear, thunderstorms, or

icing may affect flight safety. Radar vectoring is a compass heading provided by controllers to facilitate the movement of air traffic.

## En Route

The en route service area covers the airspace not included in the airport and terminal areas. Air route traffic control centers (ARTCC's) provide en route services for a large geographical area to aircraft between the departure and arrival phases of flight. The primary role of the air route traffic control center is to provide a safe, orderly, and expeditious traffic flow throughout the NAS. Services include separating instrument flight rules aircraft, monitoring traffic flow and implementing traffic management initiatives, issuing traffic and weather advisories, coordinating special use airspace, and providing emergency assistance. In addition, the air route traffic control center is the focal point for monitoring the NAS infrastructure status within its area of jurisdiction.

In the oceanic environment, the same general services are provided. However, due to lack of radar and direct communications between pilot and controller, the efficiency of the services is somewhat reduced. For example, the oceanic aircraft separation standards are much larger than domestic airspace standards.

Instrument flight rules aircraft are separately provided vertical and horizontal spacing between aircraft to ensure conflict-free flight paths. Controllers provide specific route and altitude instructions by relying on a network of radar, communications, and computers. Traffic management uses various programs to control aircraft flow rates and sequencing into and out of high-

density areas. This service reduces the possibility of any point in the NAS becoming overloaded by balancing demand and capacity.

Traffic advisory services are provided to all aircraft operating under instrument flight rules, and when requested, to aircraft under visual flight rules. These services consist of informing aircrews of other aircraft in the vicinity and providing flight information and navigation assistance. Another important advisory service is disseminating airport conditions and weather information such as icing, turbulence, and thunderstorms to aircrews. The weather information is generated from a variety of sources including pilot reports and weather radars.

Air route traffic control centers monitor the status of special use airspace within its boundaries. This airspace is used for operations such as military training, flight test activity, space shuttle operations, missile launches, and various special events. The service provided by the air route traffic control centers ensures that nonparticipating aircraft are excluded from active special use airspace, and the airspace is returned to the NAS when not in use.

Another important service provided is emergency assistance to aircraft in distress. Examples are lost aircraft, aircraft with mechanical difficulties, and medical emergencies. Controllers will do whatever is necessary to handle the incident in the most expeditious manner.

## Project/Services Relationship

The following matrix, Table 1, and a graphic at the beginning of each chapter show the relationship of R,E&D projects to FAA services.

**Table 1. R,E&D Project/FAA Services Matrix**

Project Number	Project Title	FAA Services					R,E&D Internal Services
		Aircraft/Aircrew	Flight Service	Airport	Terminal	En Route	
	<b>CAPACITY AND AIR TRAFFIC MANAGEMENT TECHNOLOGY</b>						
021-110	Advanced Traffic Management System (ATMS)		X	X	X	X	
021-140	Oceanic Air Traffic Automation					X	
021-200	Surface Movement Advisor (SMA)			X			
021-220	Multiple Runway Procedures Development			X	X		
021-230	Wake-Vortex Separation Standards			X	X	X	
022-110	Traffic Alert and Collision Avoidance System (TCAS)	X			X	X	
022-140	General Aviation and Vertical Flight Program	X	X	X	X	X	X
022-150	Flight Operations and Air Traffic Management Integration	X		X	X	X	X
023-120	Separation Standards					X	
024-110	Aviation System Capacity Planning			X	X	X	
025-110	National Simulation Capability (NSC)	X		X	X	X	X
025-130	Air Traffic Models and Evaluation Tools			X	X	X	X
025-140	System Performance and Investment Analysis		X	X	X	X	X
027-110	Automation System Assessment				X	X	X
	<b>COMMUNICATIONS, NAVIGATION, AND SURVEILLANCE</b>						
031-110	Aeronautical Data Link Communications and Applications		X	X	X	X	
031-120	Satellite Communications Program		X	X	X	X	
031-130	NAS Telecommunications for the 21st Century		X	X	X	X	
032-110	Satellite Navigation Program			X	X	X	
032-120	Navigation Systems Architecture		X	X	X	X	
	<b>WEATHER</b>						
041-110	Aviation Weather Analysis and Forecasting	X	X	X	X	X	
042-110	Aeronautical Hazards Research	X			X	X	
	<b>AIRPORT TECHNOLOGY</b>						
051-110	Airport Planning and Design Technology			X			
051-120	Airport Pavement Technology			X			
051-130	Airport Safety Technology			X			
	<b>AIRCRAFT SAFETY TECHNOLOGY</b>						
061-110	Aircraft Systems Fire Safety	X					
062-110	Advanced Materials/Structural Safety	X					
063-110	Propulsion and Fuel Systems	X					
064-110	Flight Safety/Atmospheric Hazards	X					

**Table 1. R,E&D Project/FAA Services Matrix (continued)**

Project Number	Project Title	FAA Services					R,E&D Internal Services
		Aircraft/Aircrew	Flight Service	Airport	Terminal	En Route	
065-110	Aging Aircraft	X					
066-110	Aircraft Catastrophic Failure Prevention Research	X					
067-110	Fire Research	X					
069-110	Cabin Safety	X					
	<b>SYSTEM SECURITY TECHNOLOGY</b>						
071-110	Explosives/Weapons Detection			X			
073-110	Airport Security Technology Integration			X			
075-110	Aircraft Hardening	X					
076-110	Aviation Security Human Factors			X			X
	<b>HUMAN FACTORS AND AVIATION MEDICINE</b>						
081-110	Flight Deck Human Factors	X					X
082-110	Air Traffic Control Human Factors		X	X	X	X	X
083-110	Airway Facilities Human Factors		X	X	X	X	X
084-110	Flight Deck/ATC System Integration	X			X	X	X
085-110	Aircraft Maintenance Human Factors	X					X
086-110	Aeromedical Research	X					X
	<b>ENVIRONMENT AND ENERGY</b>						
091-110	Environment and Energy	X		X		X	
	<b>INNOVATIVE/COOPERATIVE RESEARCH</b>						
101-110	Transportation Research Board (TRB)						X
101-120	FAA/NASA Joint University Program						X
101-130	Small Business Innovative Research (SBIR) Program						X
101-140	FAA/NASA Cooperative Programs						X
101-150	University Fellowship Research Program						X
101-160	Technology Transfer Program						X
101-170	Independent Research and Development (IR&D) Program						X
101-180	Aviation Research Grant Program						X

### 1.3 R,E&D Project Support of FAA Strategic Goals and Objectives

The FAA Strategic Plan is based on information gathered on global and domestic trends, likely changes in aviation, and the needs of its customers and stakeholders. Dramatic changes occurring in virtually every area of aviation demand that the FAA respond flexibly and quickly to maintain the high safety record of U.S. aviation. Additionally, the FAA has a commitment to bring new technologies on line to increase system efficiency and quality of service to its customers.

The FAA Strategic Plan focuses on the following strategic issue areas: System Safety; 21st Century Aviation; System Capacity; Industry Vitality; International Leadership; Environmental Responsibility; and the FAA Organization. The FAA's goals and objectives are keyed to these strategic issue areas. Table 2 lists the R,E&D projects supporting strategic goals and objectives delineated in the FAA Strategic Plan.

**Table 2. R,E&D Projects Supporting FAA Strategic Goals and Objectives**

<b>SYSTEM SAFETY</b>		
<b>Goal 1: Safety -- Eliminate accidents and incidents in the aviation system with a strategy that targets the most critical areas</b>		
<b>Objective 1A. Establish agency policy on safety risk assessment and risk management.</b>		
066-110 Aircraft Catastrophic Failure Prevention Research <ul style="list-style-type: none"><li>- <i>Near-term design improvements to increase fire safety in in-flight and post-crash fires</i></li></ul>		
<b>Objective 1C. Minimize aging aircraft hazards.</b>		
065-110 Aging Aircraft <ul style="list-style-type: none"><li>- <i>Means for evaluating and ensuring safety and reducing the risk associated with aging aircraft structures</i></li></ul>		
<b>Objective 1D. Minimize the risk of collisions and increase the efficiency of aircraft movements on the airport surface</b>		
021-200 Surface Movement Advisor (SMA) <ul style="list-style-type: none"><li>- <i>Enhanced surface safety system</i></li></ul>		
051-130 Airport Safety Technology <ul style="list-style-type: none"><li>- <i>New technologies in runway surfaces, visual guidance systems, airport rescue and fire-fighting, and wildlife control in the airport environment</i></li></ul>		
<b>Objective 1E. Improve FAA oversight of industry performance based on shared use of safety-related data and development of trend indicators.</b>		
062-110 Advanced Materials/Structural Safety <ul style="list-style-type: none"><li>- <i>Data to support certification standards, performance specifications and advisory circulars on crashworthiness and structural safety of advanced materials aircraft</i></li></ul>		
063-110 Propulsion and Fuel Systems <ul style="list-style-type: none"><li>- <i>Criteria, guidelines, and data for turbine and piston engine certification requirements as new fuels and materials are employed in next generation aircraft</i></li></ul>		
066-110 Aircraft Catastrophic Failure Prevention Research <ul style="list-style-type: none"><li>- <i>Near-term design improvements to increase fire safety in in-flight and post-crash fires</i></li></ul>		

\* Goal and objective numbers are those used in the 1995 FAA Strategic Plan

**Table 2. R,E&D Projects Supporting FAA Strategic Goals and Objectives (continued)**

086-110	Aeromedical Research <ul style="list-style-type: none"> <li>- <i>Recommendations and development of protective equipment or procedures and guidance for FAA regulatory and medical certification staff</i></li> </ul>
<b>Objective 1F.</b>	<b>Encourage the aviation industry to maintain high levels of safety through incentive based programs.</b>
062-110	Advanced Materials/Structural Safety <ul style="list-style-type: none"> <li>- <i>Data to support certification standards, performance specifications, and advisory circulars on crashworthiness and structural safety of advanced materials aircraft</i></li> </ul>
063-110	Propulsion and Fuel Systems <ul style="list-style-type: none"> <li>- <i>Criteria, guidelines, and data for turbine and piston engine certification requirements as new fuels and materials are employed in next generation aircraft</i></li> </ul>
066-110	Aircraft Catastrophic Failure Prevention Research <ul style="list-style-type: none"> <li>- <i>Near-term design improvements to increase fire safety in in-flight and post-crash fires</i></li> </ul>
<b>Objective 1G.</b>	<b>Reduce the likelihood of weather-related accidents by improving access and delivery of weather information, and by improving technology.</b>
031-110	Aeronautical Data Link Communications and Applications <ul style="list-style-type: none"> <li>- <i>Enhanced air traffic management communications capabilities</i></li> </ul>
041-110	Aviation Weather Analysis and Forecasting <ul style="list-style-type: none"> <li>- <i>Improved weather information, forecasts, and observations</i></li> </ul>
042-110	Aeronautical Hazards Research <ul style="list-style-type: none"> <li>- <i>Improved capability to detect, monitor, and alert flight crews to mountain-induced turbulence</i></li> </ul>
064-110	Flight Safety/Atmospheric Hazards <ul style="list-style-type: none"> <li>- <i>Technical data to support regulatory and certification processes associated with new digital technology and natural and manmade atmospheric hazards</i></li> </ul>
<b>Objective 1H.</b>	<b>Provide one level of safety to all passengers traveling on regularly scheduled commercial aircraft with more than nine seats</b>
022-110	Traffic Alert and Collision Avoidance System (TCAS) <ul style="list-style-type: none"> <li>- <i>An independent airborne collision avoidance capability</i></li> </ul>
062-110	Advanced Materials/Structural Safety <ul style="list-style-type: none"> <li>- <i>Data to support certification standards, performance specifications, and advisory circulars on crashworthiness and structural safety of advanced materials aircraft</i></li> </ul>
064-110	Flight Safety/Atmospheric Hazards <ul style="list-style-type: none"> <li>- <i>Technical data to support regulatory and certification processes associated with new digital technology and natural and manmade atmospheric hazards</i></li> </ul>
065-110	Aging Aircraft <ul style="list-style-type: none"> <li>- <i>Means for evaluating and ensuring safety and reducing the risk associated with aging aircraft structures</i></li> </ul>
067-110	Fire Research <ul style="list-style-type: none"> <li>- <i>New technologies to improve fire safety for current and future aircraft, leading to a totally fire-resistant cabin</i></li> </ul>

\* Goal and objective numbers are those used in the 1995 FAA Strategic Plan

**Table 2. R,E&D Projects Supporting FAA Strategic Goals and Objectives (continued)**

<b>Goal 2: Security -- Eliminate security incidents in the aviation system with a strategy that targets the most critical areas</b>	
<b>Objective 2A. Reduce the risk of security incidents by addressing specific vulnerabilities in the aviation system identified through risk assessment and data analysis.</b>	
071-110	Explosive/Weapons Detection <ul style="list-style-type: none"> <li>- <i>Improved systems and operational procedures to detect explosives/weapons on passengers, baggage, cargo, and mail</i></li> </ul>
073-110	Airport Security Technology Integration <ul style="list-style-type: none"> <li>- <i>New security technology and procedures integrated into airport operational environments</i></li> </ul>
075-110	Aircraft Hardening <ul style="list-style-type: none"> <li>- <i>Methods to increase aircraft survivability by reducing the effects of explosives and other terrorist actions on commercial aircraft</i></li> </ul>
076-110	Aviation Security Human Factors <ul style="list-style-type: none"> <li>- <i>Methods to maximize human performance within the aviation security system</i></li> </ul>
<b>Goal 3: Human Factors -- Eliminate human factors as a causal factor in accidents and incidents</b>	
<b>Objective 3A. Support safety and other goals by providing for systematic integration of human considerations across all agency functions (e.g., certification, regulation, and management of the National Airspace System (NAS)) during all phases of NAS design, development, and operation.</b>	
025-110	National Simulation Capability (NSC) <ul style="list-style-type: none"> <li>- <i>Support for R,E&amp;D systems engineering missions by integrating R,E&amp;D program elements across the NAS environment</i></li> </ul>
076-110	Aviation Security Human Factors <ul style="list-style-type: none"> <li>- <i>Methods to maximize human performance within the aviation security system</i></li> </ul>
081-110	Flight Deck Human Factors <ul style="list-style-type: none"> <li>- <i>Means to improve human performance and reduce the adverse effects of errors in the cockpit</i></li> </ul>
082-110	Air Traffic Control Human Factors <ul style="list-style-type: none"> <li>- <i>Guidelines to help increase controller effectiveness and reduce the likelihood of system-induced human operational errors</i></li> </ul>
083-110	Airway Facilities Maintenance Human Factors <ul style="list-style-type: none"> <li>- <i>Means to optimize human systems performance in the future Airway Facilities Organization</i></li> </ul>
084-110	Flight Deck/ATC System Integration <ul style="list-style-type: none"> <li>- <i>Means to ensure new-generation aircraft compatibilities with the evolving automated NAS</i></li> </ul>
085-110	Aircraft Maintenance Human Factors <ul style="list-style-type: none"> <li>- <i>Reduction of accidents and incidents in air carrier operations attributable to maintenance and inspection human factors</i></li> </ul>
086-110	Aeromedical Research <ul style="list-style-type: none"> <li>- <i>Recommendations and development of protective equipment or procedures and guidance for FAA regulatory and medical certification staff</i></li> </ul>

\* Goal and objective numbers are those used in the 1995 FAA Strategic Plan

**Table 2. R,E&D Projects Supporting FAA Strategic Goals and Objectives (continued)**

<u>SYSTEM CAPACITY</u>	
<b>Goal 5: Meet system capacity needs with long-term solutions and real-time resolutions of today's targeted problems.</b>	
<b>Objective 5A.</b>	<b>System Capacity Measurement -- Identify and define, in concert with the aviation community, standards of success and national capacity indicators which will better target areas for reducing delays and increasing capacity.</b>
024-110	Aviation System Capacity Planning <ul style="list-style-type: none"> <li>- <i>Recommended procedures, equipment, and physical facilities for terminal airspace that will increase capacity</i></li> </ul>
027-110	Automation System Assessment <ul style="list-style-type: none"> <li>- <i>Tools to support need-based acquisition decisions</i></li> </ul>
<b>Objective 5B.</b>	<b>Near-Term Capacity Initiatives -- Reduce constraints/limitations at the top 40 delay/operationally impacted airports by timely implementation of system enhancements and capacity increasing technologies and procedures.</b>
021-110	Advanced Traffic Management System (ATMS) <ul style="list-style-type: none"> <li>- <i>An independent airborne collision avoidance capability</i></li> </ul>
021-200	Surface Movement Advisor (SMA) <ul style="list-style-type: none"> <li>- <i>Enhanced surface safety system</i></li> </ul>
021-220	Multiple Runway Procedures Development <ul style="list-style-type: none"> <li>- <i>Air traffic control procedures to reduce airport delays by more fully using multiple-runway capacity during instrument meteorological conditions</i></li> </ul>
021-230	Wake-vortex Separation Standards <ul style="list-style-type: none"> <li>- <i>Safely reducing separation standards through wake vortex research</i></li> </ul>
022-150	Flight Operations and Air Traffic Management Integration <ul style="list-style-type: none"> <li>- <i>Capability to integrate flight management computer operations with ground-based air traffic management automation</i></li> </ul>
024-110	Aviation System Capacity Planning <ul style="list-style-type: none"> <li>- <i>Recommended procedures, equipment, and physical facilities for terminal airspace that will increase capacity</i></li> </ul>
025-110	National Simulation Capability (NSC) <ul style="list-style-type: none"> <li>- <i>Support for R,E&amp;D systems engineering missions by integrating R,E&amp;D program elements across the NAS environment</i></li> </ul>
025-130	Air Traffic Models and Evaluation Tools <ul style="list-style-type: none"> <li>- <i>Modeling and analytic tools to support operational improvements</i></li> </ul>
031-110	Aeronautical Data Link Communications and Applications <ul style="list-style-type: none"> <li>- <i>Enhanced air traffic management communications capabilities</i></li> </ul>
051-120	Airport Pavement Technology <ul style="list-style-type: none"> <li>- <i>Standards for pavement design, evaluation, materials, construction, and repairs</i></li> </ul>

\* Goal and objective numbers are those used in the 1995 FAA Strategic Plan

**Table 2. R,E&D Projects Supporting FAA Strategic Goals and Objectives (continued)**

<b>Objective 5C.</b>	<b>Air Traffic Control (ATC) Automation -- Improve the automated infrastructure through replacement and enhancement in order to provide the platform for capacity-enhancing technologies and procedures.</b>
021-110	Advanced Traffic Management System (ATMS) - <i>An independent airborne collision avoidance capability</i>
021-140	Oceanic Air Traffic Automation - <i>Enhanced automation capabilities to increase oceanic air traffic capacity and efficiency</i>
021-200	Surface Movement Advisor (SMA) - <i>Enhanced surface safety system</i>
025-110	National Simulation Capability (NSC) - <i>Support for R,E&amp;D systems engineering missions by integrating R,E&amp;D program elements across the NAS environment</i>
027-110	Automation System Assessment - <i>Tools to support need-based acquisition</i>
031-110	Aeronautical Data Link Communications and Applications - <i>Enhanced air traffic management communications capabilities</i>
<b>Objective 5D.</b>	<b>Traffic Flow Management -- Create the necessary capabilities to permit the ATC system to ensure safe separation while imposing minimum constraints on system users and aircraft movement.</b>
021-110	Advanced Traffic Management System (ATMS) - <i>An independent airborne collision avoidance capability</i>
021-200	Surface Movement Advisor (SMA) - <i>Enhanced surface safety system</i>
021-220	Multiple Runway Procedures Development - <i>Air traffic control procedures to reduce airport delays by more fully using multiple-runway capacity during instrument meteorological conditions</i>
021-230	Wake-vortex Separation Standards - <i>Safely reducing separation standards through wake vortex research</i>
022-110	Traffic Alert and Collision Avoidance System (TCAS) - <i>An independent airborne collision avoidance capability</i>
022-150	Flight Operations and Air Traffic Management Integration - <i>Capability to integrate flight management computer operations with ground-based air traffic management automation</i>
023-120	Separation Standards - <i>Quantitative guidance for domestic and international efforts to establish minimum vertical and horizontal separation standards</i>
031-120	Satellite Communications Programs - <i>Standards and testing to support mobile satellite communication operational use for civil aviation</i>
032-110	Satellite Navigation Program - <i>Standards and methods to use satellite navigation signals to meet civil aviation requirements</i>

\* Goal and objective numbers are those used in the 1995 FAA Strategic Plan

**Table 2. R,E&D Projects Supporting FAA Strategic Goals and Objectives (continued)**

<b>Objective 5E.</b>	<b>Oceanic Control -- Change, in concert with the international aviation community, oceanic air traffic control from its current non-radar control to a tactical control environment much like the current domestic radar control.</b>
021-140	<b>Oceanic Air Traffic Automation</b> - <i>Enhanced automation capabilities to increase oceanic air traffic capacity and efficiency</i>
023-120	<b>Separation Standards</b> - <i>Quantitative guidance for domestic and international efforts to establish minimum vertical and horizontal separation standards</i>
031-120	<b>Satellite Communications Programs</b> - <i>Standards and testing to support mobile satellite communication operational use for civil aviation</i>
031-130	<b>NAS Telecommunications for the 21st Century</b> - <i>Improved air/ground and ground/ground communications systems</i>
<b>Objective 5F.</b>	<b>Weather Forecasting, Detection and Communication -- Reduce the capacity-impacting consequences of weather phenomena by improved weather forecasts and increased accuracy, resolution, and dissemination of observations on the ground and in the air.</b>
031-110	<b>Aeronautical Data Link Communications and Applications</b> - <i>Enhanced air traffic management communications capabilities</i>
041-110	<b>Aviation Weather Analysis and Forecasting</b> - <i>Improved weather information, forecasts, and observations</i>
042-110	<b>Aeronautical Hazards Research</b> - <i>Improved capability to detect, monitor, and alert flight crews to mountain-induced turbulence</i>
<b>Objective 5G.</b>	<b>Communication, Navigation and Surveillance (CNS), and Satellite Navigation -- Implement CNS and satellite navigation capabilities through an aggressive Industry/Government partnership that achieves user benefits in all phases of aviation operations.</b>
032-110	<b>Satellite Navigation Program</b> - <i>Standards and methods to use satellite navigation signals to meet civil aviation requirements</i>
032-120	<b>Navigation Systems Architecture</b> - <i>The strategy for transitioning to satellite technology</i>
<b>Objective 5H.</b>	<b>Communication/Data Link -- Provide a cost-effective communications infrastructure to enhance the safety and effectiveness of air traffic management operations.</b>
022-150	<b>Flight Operations and Air Traffic Management Integration</b> - <i>Capability to integrate flight management computer operations with ground-based air traffic management automation</i>
031-110	<b>Aeronautical Data Link Communications and Applications</b> - <i>Enhanced air traffic management communications capabilities</i>

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**Table 2. R,E&D Projects Supporting FAA Strategic Goals and Objectives (continued)**

031-120	Satellite Communications Programs
	<ul style="list-style-type: none"> <li>- <i>Standards and methods to use satellite navigation signals to meet civil aviation requirements</i></li> </ul>
031-130	NAS Telecommunications for the 21st Century
	<ul style="list-style-type: none"> <li>- <i>Improved air/ground and ground/ground communications systems</i></li> </ul>
<b>Objective 5I.</b>	<b>Airport Planning -- Improve the national airport planning process by: adding a method for prioritizing projects; linking the national plan to the program through an Airports Capital Improvement Program (CIP); and developing the Airports Research, Engineering, and Development (R,E&amp;D) program.</b>
051-110	Airport Planning and Design Technology
	<ul style="list-style-type: none"> <li>- <i>Design standards and advisory information for runways, taxiways, aprons, gates, airports, terminals, and ground access systems</i></li> </ul>
051-120	Airport Pavement Technology
	<ul style="list-style-type: none"> <li>- <i>Standards for pavement design, evaluation, materials, construction, and repairs</i></li> </ul>
051-130	Airport Safety Technology
	<ul style="list-style-type: none"> <li>- <i>New technologies in runway surfaces, visual guidance systems, airport rescue and fire-fighting, and wildlife control in the airport environment</i></li> </ul>
<b>Objective 5J.</b>	<b>Implement new automation technologies and associated functional improvements in a manner that fully accounts for the proper role of people in the system.</b>
025-110	National Simulation Capability (NSC)
	<ul style="list-style-type: none"> <li>- <i>Support for R,E&amp;D systems engineering missions by integrating R,E&amp;D program elements across the NAS environment</i></li> </ul>
082-110	Air Traffic Control Human Factors
	<ul style="list-style-type: none"> <li>- <i>Guidelines to help increase controller effectiveness and reduce the likelihood of system-induced human operational errors</i></li> </ul>
083-110	Airway Facilities Maintenance Human Factors
	<ul style="list-style-type: none"> <li>- <i>Means to optimize human systems performance in the future Airway Facilities Organization</i></li> </ul>
084-110	Flight Deck/ATC System Integration
	<ul style="list-style-type: none"> <li>- <i>Means to ensure new-generation aircraft compatibilities with the evolving automated NAS</i></li> </ul>
<b><u>INDUSTRY VITALITY</u></b>	
<b>Goal 6:</b>	<b>Promote U.S. aviation and U.S. preeminence in the global aviation system.</b>
<b>Objective 6A.</b>	<b>Promote international harmonization through cooperative efforts to align certification, operational, and maintenance standards, practices, and procedures</b>
021-140	Oceanic Air Traffic Automation
	<ul style="list-style-type: none"> <li>- <i>Enhanced automation capabilities to increase oceanic air traffic capacity and efficiency</i></li> </ul>
022-110	Traffic Alert and Collision Avoidance System (TCAS)
	<ul style="list-style-type: none"> <li>- <i>An independent airborne collision avoidance capability</i></li> </ul>
023-120	Separation Standards
	<ul style="list-style-type: none"> <li>- <i>Quantitative guidance for domestic and international efforts to establish minimum vertical and horizontal separation standards</i></li> </ul>

\* Goal and objective numbers are those used in the 1995 FAA Strategic Plan

**Table 2. R,E&D Projects Supporting FAA Strategic Goals and Objectives (continued)**

031-110	Aeronautical Data Link Communications and Applications - <i>Enhanced air traffic management communications capabilities</i>
031-120	Satellite Communications Programs - <i>Standards and testing to support mobile satellite communication operational use for civil aviation</i>
031-130	NAS Telecommunications for the 21st Century - <i>Improved air/ground and ground/ground communications</i>
032-110	Satellite Navigation Program - <i>Standards and methods to use satellite navigation signals to meet civil aviation requirements</i>
061-110	Aircraft Systems Fire Safety - <i>Near-term design improvements to increase fire safety in in-flight and post-crash fires</i>
065-110	Aging Aircraft - <i>Means for evaluating and ensuring safety and reducing the risk associated with aging aircraft structures</i>
069-110	Cabin Safety - <i>Coordination of the diverse cabin safety research activities on an international level</i>
<b>Goal 7: Increase, with a sense of urgency, the efficiency of the air transportation system.</b>	
<b>Objective 7A.</b>	Implement a comprehensive, agency-wide general aviation program that demonstrates the FAA's commitment to preserve and revitalize the general aviation industry.
022-140	General Aviation and Vertical Flight Program - <i>Introduction and expansion of technology into the NAS for general aviation (conventional and advanced design) fixed and rotary wing aircraft</i>
<b>Objective 7B.</b>	Revitalize the regulatory process, using industry and public input, to expedite rule-making development and reduce economic burden while maintaining the highest level of safety and environmental protection.
076-110	Aviation Security Human Factors - <i>Methods to maximize human performance within the aviation security system</i>
091-110	Environment and Energy - <i>Regulations and tools to control and evaluate the environmental impact of aviation</i>
<b>Objective 7C.</b>	FAA will help aviation reduce the costs of flying by making the air traffic management system more efficient to use and avoiding the imposition of undue regulatory costs on all categories of aviation.
021-110	Advanced Traffic Management System (ATMS) - <i>An independent airborne collision avoidance capability</i>
021-200	Surface Movement Advisor (SMA) - <i>Enhanced surface safety system</i>
021-220	Multiple Runway Procedures Development - <i>Air traffic control procedures to reduce airport delays by more fully using multiple-runway capacity during instrument meteorological conditions</i>

\* Goal and objective numbers are those used in the 1995 FAA Strategic Plan

**Table 2. R,E&D Projects Supporting FAA Strategic Goals and Objectives (continued)**

025-110	National Simulation Capability (NSC) <ul style="list-style-type: none"> <li>- <i>Support for R,E&amp;D systems engineering missions by integrating R,E&amp;D program elements across the NAS environment</i></li> </ul>
025-130	Air Traffic Models and Evaluation Tools <ul style="list-style-type: none"> <li>- <i>Modeling and analytic tools to support operational improvements</i></li> </ul>
025-140	System Performance and Investment Analysis <ul style="list-style-type: none"> <li>- <i>Broad objective analysis support for evaluating R,E&amp;D investment options</i></li> </ul>
032-120	Navigation Systems Architecture <ul style="list-style-type: none"> <li>- <i>The strategy for transitioning to satellite technology</i></li> </ul>
<b><u>INTERNATIONAL LEADERSHIP</u></b>	
<b>Goal 8: Achieve, through U.S. leadership, international standardization of a safe and efficient global air transportation system</b>	
Objective 8A.	Provide world leadership in the enhancement of global aviation safety and efficiency by collaborating with the international community on policy and operational initiatives.
021-140	Oceanic Air Traffic Automation <ul style="list-style-type: none"> <li>- <i>Enhanced automation capabilities to increase oceanic air traffic capacity and efficiency</i></li> </ul>
022-110	Traffic Alert and Collision Avoidance System (TCAS) <ul style="list-style-type: none"> <li>- <i>An independent airborne collision avoidance capability</i></li> </ul>
023-120	Separation Standards <ul style="list-style-type: none"> <li>- <i>Quantitative guidance for domestic and international efforts to establish minimum vertical and horizontal separation standards</i></li> </ul>
031-110	Aeronautical Data Link Communications and Applications <ul style="list-style-type: none"> <li>- <i>Enhanced air traffic management communications capabilities</i></li> </ul>
031-120	Satellite Communications Programs <ul style="list-style-type: none"> <li>- <i>Standards and testing to support mobile satellite communication operational use for civil aviation</i></li> </ul>
031-130	NAS Telecommunications for the 21st Century <ul style="list-style-type: none"> <li>- <i>Improved air/ground and ground/ground communications systems</i></li> </ul>
032-110	Satellite Navigation Program <ul style="list-style-type: none"> <li>- <i>Standards and methods to use satellite navigation signals to meet civil aviation requirements</i></li> </ul>
061-110	Aircraft Systems Fire Safety <ul style="list-style-type: none"> <li>- <i>Near-term design improvements to increase fire safety in in-flight and post-crash fires</i></li> </ul>
062-110	Advanced Materials/Structural Safety <ul style="list-style-type: none"> <li>- <i>Data to support certification standards, performance specifications, and advisory circulars on crashworthiness and structural safety of advanced materials aircraft</i></li> </ul>
064-110	Flight Safety/Atmospheric Hazards <ul style="list-style-type: none"> <li>- <i>Technical data to support regulatory and certification processes associated with new digital technology and natural and manmade atmospheric hazards</i></li> </ul>

\* Goal and objective numbers are those used in the 1995 FAA Strategic Plan

**Table 2. R,E&D Projects Supporting FAA Strategic Goals and Objectives (continued)**

065-110	Aging Aircraft	- <i>Means for evaluating and ensuring safety and reducing the risk associated with aging aircraft structures</i>
069-110	Cabin Safety	- <i>Coordination of the diverse cabin safety research activities on an international level</i>
<b>Objective 8B.</b>	<b>Reduce international regulatory costs to industry through harmonization, regulatory cooperation, and joint research and implementation of new technologies.</b>	
069-110	Cabin Safety	- <i>Coordination of the diverse cabin safety research activities on an international level</i>
<b>Objective 8C.</b>	<b>Provide technical assistance and training to enhance international aviation safety and security.</b>	
065-110	Aging Aircraft	- <i>Means for evaluating and ensuring safety and reducing the risk associated with aging aircraft structures</i>
<b><u>ENVIRONMENTAL RESPONSIBILITY</u></b>		
<b>Goal 9: Provide strong leadership in mitigating the adverse environmental impact of aviation.</b>		
<b>Objective 9A.</b>	<b>Reduce the impact of aircraft noise by 80 percent (based upon population by 2000, through an optimal mix of new aircraft certification standards, operational procedures, land use initiatives, and technology)</b>	
022-140	General Aviation and Vertical Flight Program	- <i>Introduction and expansion of technology into the NAS for general aviation (conventional and advanced design) fixed and rotary wing aircraft</i>
025-140	System Performance and Investment Analysis	- <i>Broad objective analysis support for evaluating R,E&amp;D investment options</i>
091-110	Environment and Energy	- <i>Regulations and tools to control and evaluate the environmental impact of aviation</i>
<b>Objective 9B.</b>	<b>Define and minimize the impact of aircraft emissions, through an optimal mix of new aircraft certification standards, operational procedures, and technology.</b>	
091-110	Environment and Energy	- <i>Regulations and tools to control and evaluate the environmental impact of aviation</i>
<b>Objective 9C.</b>	<b>Create an environmentally effective and responsive FAA both domestically and internationally.</b>	
025-130	Air Traffic Models and Evaluation Tools	- <i>Modeling and analytic tools to support operational improvements</i>
091-110	Environment and Energy	- <i>Regulations and tools to control and evaluate the environmental impact of aviation</i> - <i>New security technology and procedures integrated into airport operational environments</i>

\* Goal and objective numbers are those used in the 1995 FAA Strategic Plan

## 2.0 CAPACITY AND AIR TRAFFIC MANAGEMENT TECHNOLOGY

A major FAA Research, Engineering and Development (R,E&D) aim is to increase air traffic control (ATC) system capacity. Automating the ATC information gathering process is already advanced, but requires major improvement and augmentation in the supporting technologies. The need to help controllers/system managers cope successfully and efficiently with increasing numbers of more demanding and capable aircraft requires introducing automation aids for conducting the ATC process itself. While in the past it was possible to spread the work among a variety of separable functions (oceanic, en route, terminal, tower/airport, etc.), efficient operations now demand carefully integrating and managing aircraft flows throughout the operating regime without artificial "walls."

Increasingly, the air traffic management (ATM) process and its supporting elements must be considered a single system. In the following material, the term "air traffic control" refers to the tactical safety separation service that prevents collisions

between aircraft and between aircraft and obstructions. "Traffic flow management" refers to the process that allocates traffic flows to scarce capacity resources. "Air traffic management" is the composite process ensuring safe, efficient, and expeditious aircraft movement. Air traffic control and traffic flow management are components of the air traffic management process.

Further ATM system development must be evolutionary. There is often the temptation to design on a "clean sheet of paper" to take full advantage of new capabilities that new technology offers. The reality is that transition and integration are the most difficult institutional problems facing system designers. However, while change in the system will be evolutionary, the design for the future is intended to provide a well understood, manageable, cost-effective improvement sequence. These improvements will keep pace with user needs for safety, capacity, efficiency, and environmental demands.

### DEVELOPMENT CHALLENGES

The FAA R,E&D efforts needed to achieve increased ATM system capacity and to introduce automation technology represent a major effort with many important challenges to the FAA's and the Nation's R,E&D community. Among the many challenges, the following may stand out in importance:

- To develop a system architecture and create a system design that recognizes and accommodates the full ATM system demands as an integrated whole.

- To establish the appropriate balance between the basic ATC separation processes and the overlying flow management/control system.
- To establish the best ways for controllers/system managers to interact with and effectively use automation systems to handle more variables safely and efficiently.
- To achieve the correct balance between strategic planning, tactical execution, and modifying the ATM as near as possible to the

flight environment. This balance will be accomplished by rapid information exchange from all available sources, and by using alternative plans created by rule-based computers.

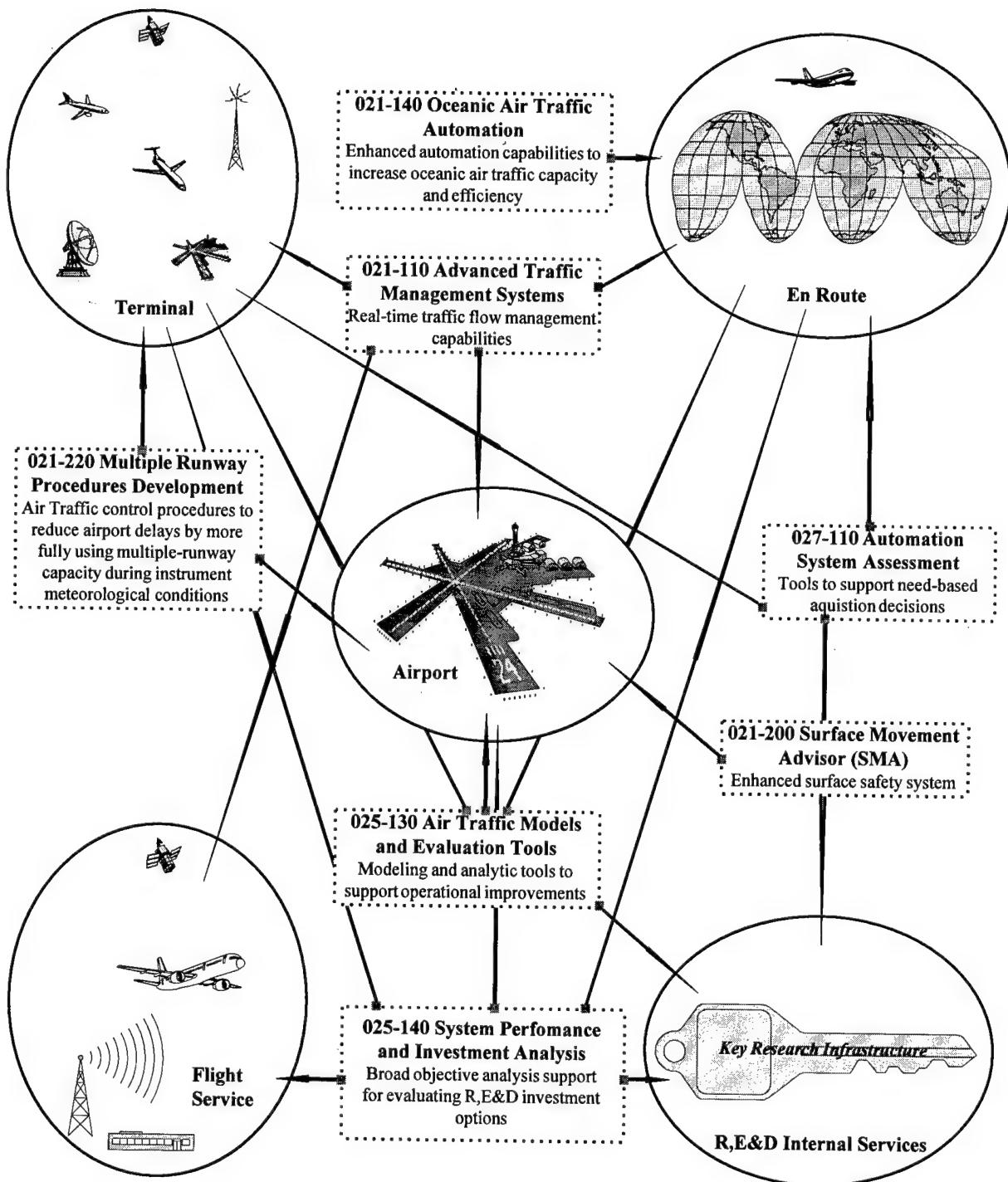
- To establish the best tactical responsibility balance between participating flightcrews with increasingly capable aircraft systems and the centralized ATM system.
- To achieve basic increases in airport capacity and en route/transition sector capacity.
- To create a digital communications system architecture that permits implementing a variety of data link services (space, terrestrial, airport surface, administrative) without

requiring multiple data links or excessive overhead communication burdens.

- To create a new level of safety and operational efficiency by developing a full-time airport surface traffic management system.
- To create an ATM system for oceanic areas and remote land areas that emulates United States domestic airspace standards by using new surveillance, navigation, and communications technologies.
- To use environmental information from participating aircraft in operating the ATM system.

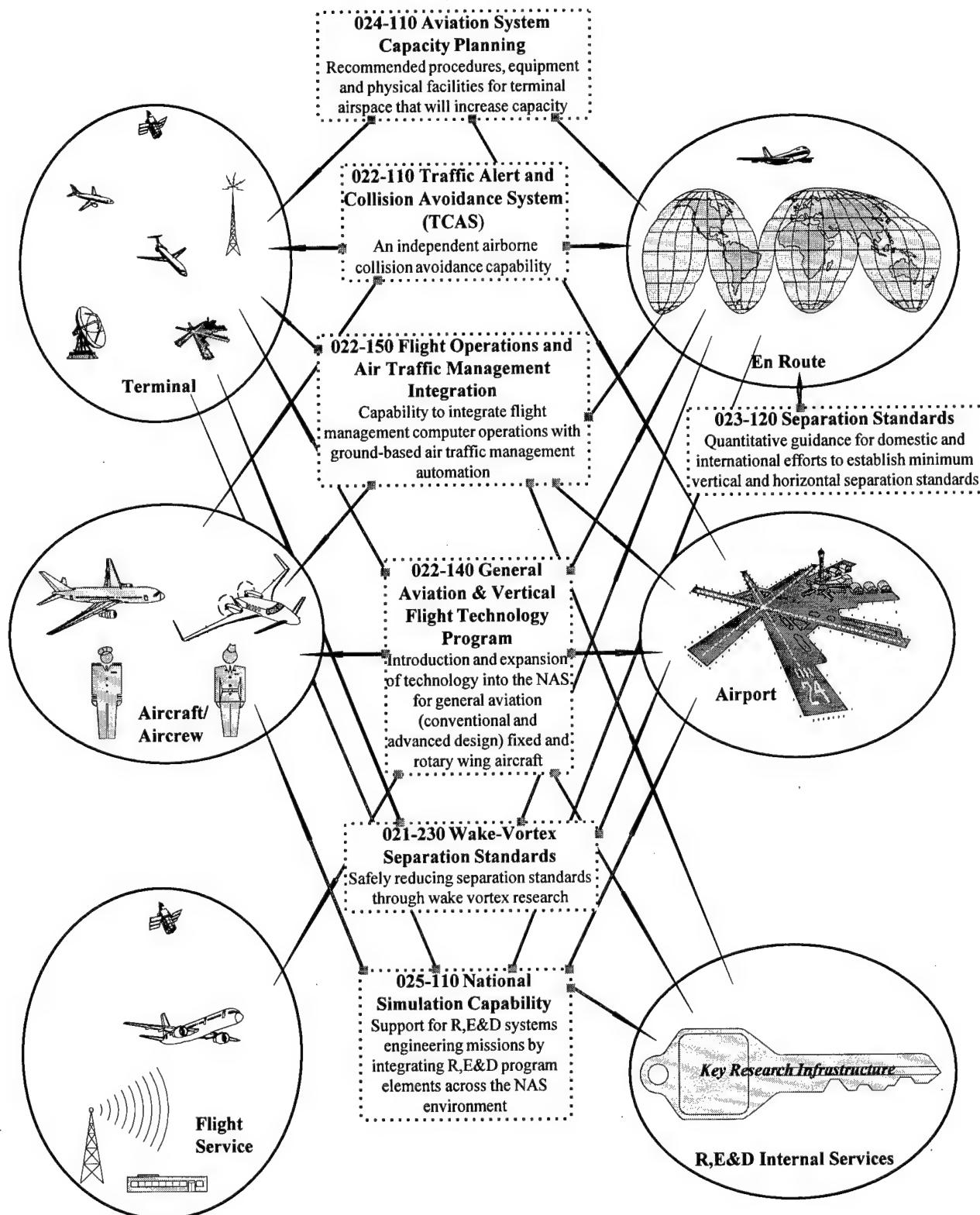
# Capacity and Air Traffic Management Technology Projects

## Contributions to FAA Services



# Capacity and Air Traffic Management Technology Projects

## Contributions to FAA Services



## 2.1 Capacity and ATM Technology Project Descriptions

### 021-110 Advanced Traffic Management System (ATMS)

**P**urpose: The ATMS project produces near-term improvements and long-term enhancements to traffic flow management (TFM) capabilities for the Air Traffic Control System Command Center (ATCSCC) and traffic management units located at en route and terminal facilities. The project will develop automated capabilities to enhance and better manage system capacity resources and eliminate unnecessary flow restrictions. In addition, the project will explore alternative technologies and procedures that will enable the aviation industry to more fully participate in the generation of national flow management strategies. The result will reduce operating costs and flight delays through a more efficient and effective national flow management process.

**Approach:** This project addresses two major interrelated research initiatives: real-time operational flow management decision support tools and FAA/industry collaborative decisionmaking. New traffic flow management concepts and/or the refinement of existing concepts are derived from extensive interactions among the research community, system operators, and National Airspace System (NAS) users. Those ideas and concepts having the greatest potential for operational benefits and return on investment are incorporated into the research program for further evaluation and development.

The development approach utilizes prototyping to explore, refine, and evaluate evolving traffic flow management capabilities for timely transition to the operational system. This prototyping method relies heavily on direct FAA and NAS user involvement.

To facilitate operational implementation of traffic flow management functionality, the research

testbed is a clone of the operational system. All potential TFM functionality including TFM functions inherent in other air traffic automation research projects is incorporated into the ATMS testbed for integration and operational evaluation. Following operational evaluations by traffic flow managers and acceptance by the operating service as a requirement, the functionality is transitioned to the operational system.

**Related Projects:** 021-140 Oceanic Air Traffic Automation, 022-150 Flight Operations and Air Traffic Management Integration, and 027-110 Automation System Assessment. Capital Investment Plan projects: A-05 Traffic Management System (TMS), F-14 System Support Laboratory Sustained Support, and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### Products:

##### Real-Time Operational Flow Management Capabilities

- Strategy Generation Tools
  - Automated re-route function
  - Multiple airport scheduler function
  - System optimization function
- Strategy Evaluation Tools
  - Strategy evaluation function
  - Daily flow simulation model (FLOWSIM)
- Special use airspace management tools

- Flight schedule monitor (FSM)

#### FAA/Industry Collaborative Decisionmaking

- Aircraft situation display flow data to industry
- FAA/industry data exchange
- Enhanced FAA/industry collaboration technologies and techniques

#### **1996 Projected Accomplishments:**

- Transition automated demand resolution (ADR) re-route function to facilities and equipment (F&E).
- Transition ADR multiple airport scheduler function to F&E.
- Incorporate FSM functionality into the ATMS testbed.
- Evaluate FAA/industry data exchange capability.

#### **Planned Activities:**

##### Real-Time Flow Management Capabilities

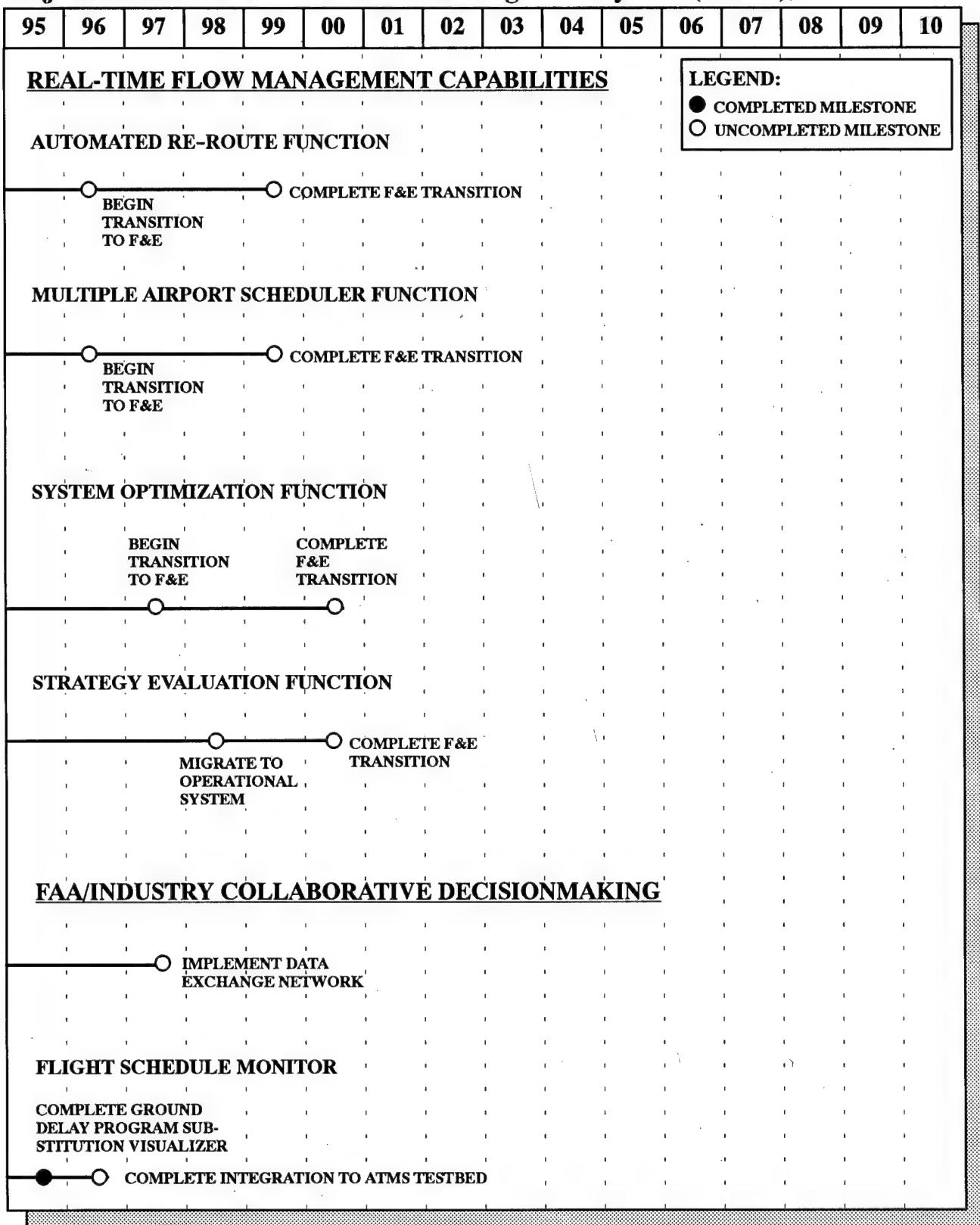
The remaining discrete traffic flow management functions that incorporate en route congestion, airport dynamics, weather conditions, and military airspace usage will be developed and evaluated through 1999. These TFM functions will provide incremental enhancements to generate real-time, system level, alternative national flow management strategies that reflect demand, weather, and special use airspace conditions.

In 1997, the system optimization function is expected to begin transition to the operational system, followed by the strategy evaluation function in 1998, with projected project completion by 2000. The strategy evaluation function will provide the capability to compute real-time operational impact analysis on alternative national flow management strategies.

##### FAA/Industry Collaborative Decisionmaking

In 1997, the FAA/industry data exchange network will be implemented. This network will provide the foundation for incremental and evolutionary enhancements to the technical and procedural capabilities that support the FAA's traffic flow management decisionmaking processes.

# Project 021-110: Advanced Traffic Management System (ATMS)



## LEGEND:

- COMPLETED MILESTONE
- UNCOMPLETED MILESTONE

## 021-140 Oceanic Air Traffic Automation

**P**urpose: With radar coverage unavailable and aircraft navigation limited to onboard systems, the current oceanic air traffic control system is significantly different from the domestic NAS. In addition to being largely manual, the system depends on air/ground communications through a third party via HF radio, subject to atmospheric anomalies and human error, to obtain position reports and maintain aircraft separation. This lack of reliable and timely position information in turn requires large aircraft separation standards, severely limiting the useable system capacity. As a result, oceanic users are rarely able to obtain maximum fuel efficiency, minimum travel times, and access to preferred takeoff times and flight paths. This project is aimed at developing new abilities to increase oceanic air traffic capacity and efficiency without degrading safety. Research and development in this project will provide the foundation for new initiatives that will be pursued through F&E, leading to the introduction of free flight in oceanic airspace.

**Approach:** Research and development for automation of the oceanic air traffic control system will support the objectives of the advanced oceanic automation system (AOAS) being developed and implemented through the oceanic system development and support (OSDS) contract and other related activities. The OSDS effort will proceed through five separate phases to develop and implement new technologies gradually. This approach will reduce technical risk, increase operator involvement in the development process, and deliver capabilities to the user community as soon as possible. In addition to the OSDS contract, studies and analyses in related areas will provide insight into areas such as system safety, measurement of benefits to users, and changes needed in international standards and procedures to fully utilize new technology.

In addition to AOAS and OSDS efforts, two prototypes currently under development will continue in support of Phase 1 of the OSDS. An

oceanic data link (ODL) prototype will allow direct controller/pilot data communications via satellite. The prototype ODL will be expanded from a one-sector to a multi-sector prototype at the Oakland Center. This capability will allow for a dramatic increase of service and user-preferred routings in the oceanic domain. The second prototype, the air traffic services interfacility data communications (AIDC), will exchange flight planning information between adjacent foreign flight information regions such as Canada and Russia. AIDC is designed to eliminate time-consuming manual operator inputs and the bulk of time-consuming voice coordination across international boundaries.

Phase 1 will provide a national oceanic data link based on the ODL prototype and AIDC described above at all oceanic facilities. Additional research and development activities leading to this objective include development of interfaces between the prototype ODL and related operational systems, and development and test of a prototype capability to process automatic dependent surveillance (ADS) data.

Phase 2 will provide the infrastructure necessary to support system enhancements in subsequent phases. Research and development activities leading to this objective include analysis of options for communication processor replacement, development of prototype means to reduce the use of paper flight strips, development of a prototype flight data processor replacement, and related studies and analyses.

Phase 3 will provide enhancements and new capabilities to automate flight separation planning and verification. Research and development activities supporting this objective include development of a prototype aeronautical telecommunications network-compliant communications capability, including full ADS capability, development of a prototype advanced conflict probe function, development of prototype integrated

display capabilities, and related studies and analyses.

Phase 4 will develop and deploy oceanic traffic flow management and air traffic control applications that support optimization of oceanic operations. Research and development activities supporting this objective include development of a prototype interface between the oceanic system and the national traffic management system, development of prototype interfaces, functionality, and display for weather and turbulence information, development of prototype conflict resolution aid capabilities, and development of prototype capabilities for automatic flight plan initiation and handoff.

Phase 5 will include residual tasks necessary for completing development of the end-state AOAS. Research and development activities supporting this task include requirements analysis and development of prototypes for the remaining capabilities to reach the targeted functionality.

**Related Projects:** 021-110 Advanced Traffic Management System (ATMS), 023-120 Separation Standards, 025-110 National Simulation Capability (NSC), 027-110 Automation System Assessment, 031-110 Aeronautical Data Link Communications and Applications, 031-120 Satellite Communications Program, and 032-110 Satellite Navigation Program. Capital Investment Plan projects: A-10 Oceanic Automation Program (OAP), F-14 System Support Laboratory Sustained Support, and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- Oceanic data link prototype and related system interfaces
- Prototype automatic dependant surveillance data processing capability

- Air traffic services interfacility data communications prototype
- Prototype oceanic flight data processor replacement
- Prototype means to reduce use of paper flight strips
- Prototype aeronautical telecommunications network compliant communications capability
- Prototype advanced conflict probe
- Prototype integrated display capability
- Prototype oceanic/national traffic management system interface
- Prototype oceanic weather/turbulence information systems
- Prototype conflict resolution aid capabilities
- Prototype automatic flight plan initiation and handoff capability

#### **1996 Projected Accomplishments:**

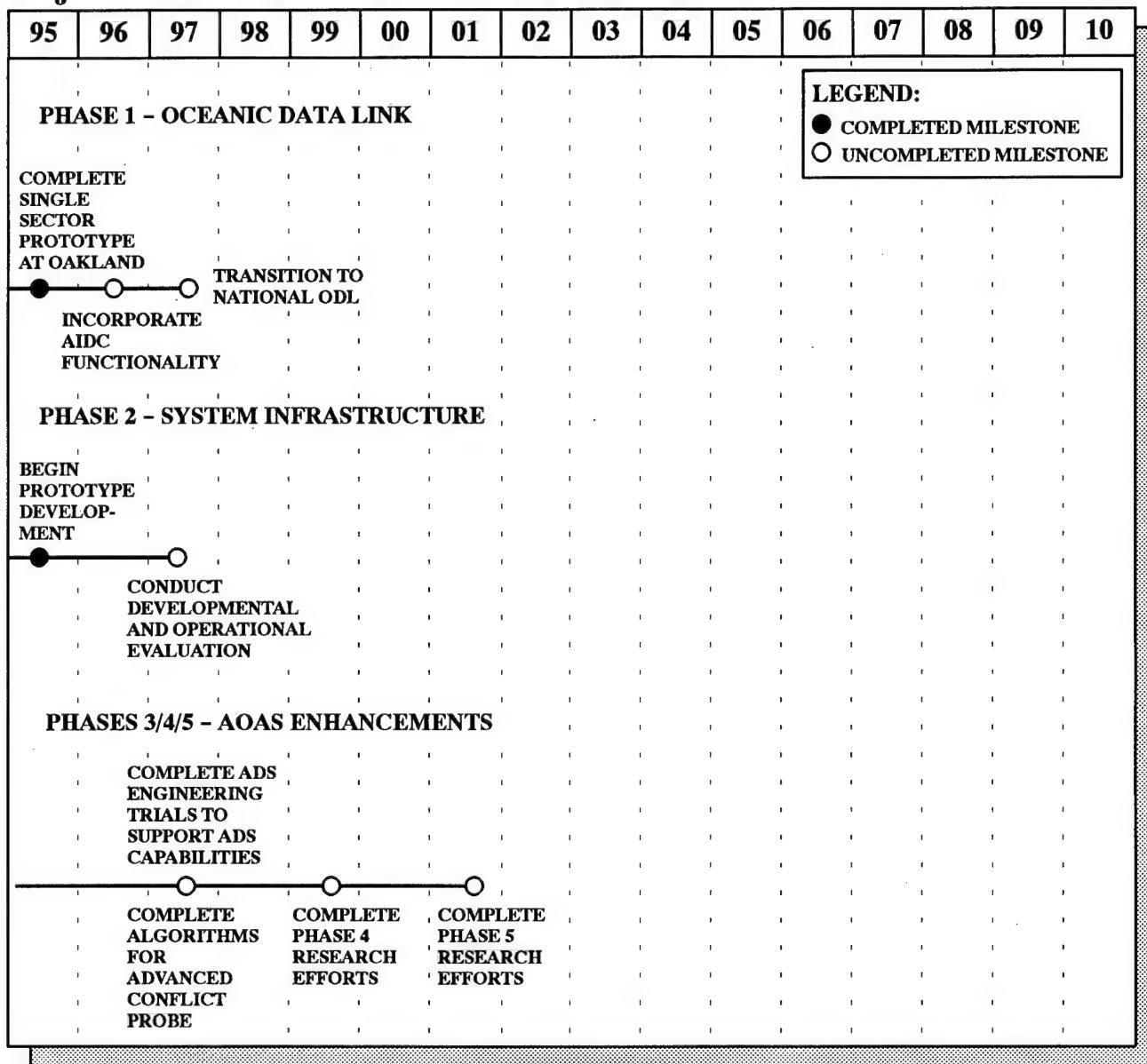
- Implement multi-sector ODL prototype at the Oakland Center.
- Complete ODL system requirements analysis.
- Develop prototype capabilities to enhance flight data processing.
- Install track advisory prototype at New York and Anchorage Centers.

- Install AIDC flight information region-to-flight information region data link prototype in Canada and Portugal.
- Publish volcanic ash study following NASA satellite launch.

**Planned Activities:** In 1997, air traffic services interfacility data communication functionality will be transitioned into Phase 1, the national ODL. The flight data processor replacement will be developed in Phase 2 of the advanced oceanic

automation system and deployed at the Oceanic Development Facility for developmental and operational evaluation. Also in 1997, Phase 3 activities will be conducted concurrently with the continuing Phase 1 and 2 activities. Phase 3 activities will include conducting ADS engineering trials and developing algorithms for the advanced conflict probe. These activities will be followed in 1998–1999 by Phase 4 research efforts. Research efforts for Phase 5 will be completed in 2000–2001.

## Project 021-140: Oceanic Air Traffic Automation



## 021-200: Surface Movement Advisor (SMA)

**P**urpose: Surface congestion, caused by a lack of coordinated surface information, can create havoc for both arrivals and departures and place a “choke-hold” on an airport. All airport users share two major goals: moving arrivals promptly off the runway to parking, and minimizing departure delays. The surface movement advisor will interface with and enhance other NAS management systems and coordinate surface activities with air traffic control, the airlines, and airport operators through an unprecedented sharing of dynamic, operationally critical surface movement information.

**Approach:** To safely increase the capacity of existing airports, more efficient use must be made of existing airport surface resources such as taxiways, aprons, aircraft servicing facilities, runways, and gates. To address the problems associated with ground taxi delays at large airports, the surface movement advisor will provide its airport user community with automated aircraft surface identification, dynamic load and resource analysis, and tracking data. SMA is an airport automation system which facilitates the unprecedented sharing of information among the air traffic, airlines, and airport operations communities to augment decision making regarding the surface movement of aircraft, thus reducing delays and helping optimize airport capacity.

The FAA and NASA are together developing a series of SMA prototypes increasing in functionality over time. These prototypes will be built at relatively modest cost through resource sharing between government agencies, which allows faster and cheaper development than would be possible through a traditional research and development procurement with industry.

This project will also coordinate with NASA to develop a virtual-reality simulation of a Level 5

control tower/airport with 360-degree visual coverage and full operational functionality. This Surface Development and Test Facility (SDTF) will provide a means to develop and test the functionality without any impact on operations at an actual commercial airport. The facility enables rigorous evaluation and validation of alleged operational and financial benefits of new functionalities and emerging technologies. The additional benefits provided by this test facility will include the capability of conducting in-depth studies using controllers, airlines dispatchers, and airport operators in an operational tower setting. This human-centered design process will enable the identification of tower user and operational requirements issues early in the SMA development process. Studies conducted in the SDTF will also be used as a basis for cost benefit and risk analysis to determine ergonomics, efficiency, and safety issues before future new tower systems are deployed in the field.

**Related Projects:** 021-110 Advanced Traffic Management System (ATMS) and 027-110 Automation System Assessment. Capital Investment Plan projects: A-02 Tower Automation Program, A-05 Traffic Management System (TMS), A-11 Terminal Air Traffic Control Automation (TATCA), and A-12 Airport Surface Target Identification System (ATIDS).

### Products:

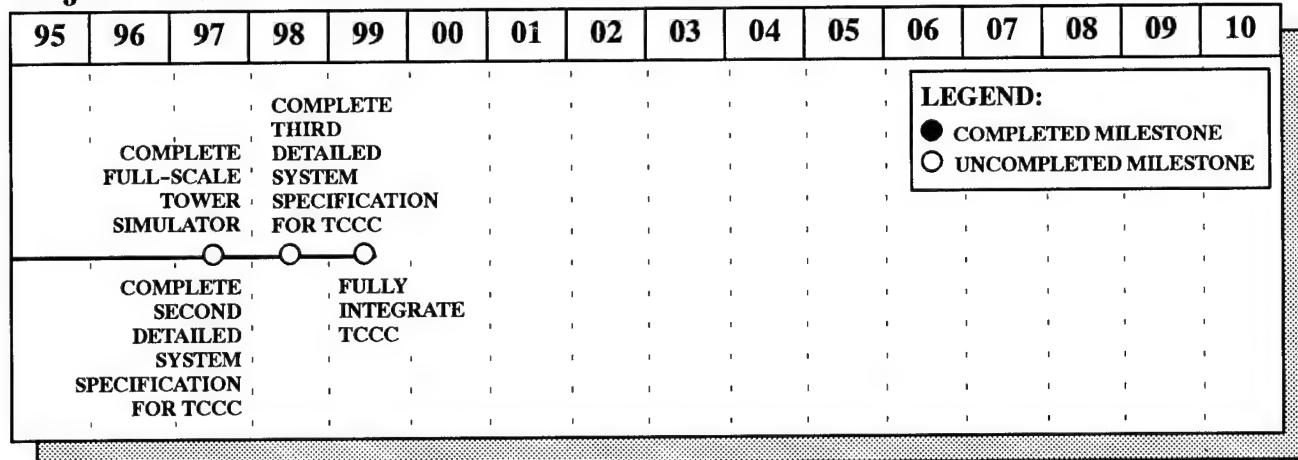
- Concept development and demonstration
- Communications architecture
- Reproduction prototype and testbed
- System specification

- Dynamic surface traffic management planning process for arrivals, departures, and taxiing aircraft
- Capability for automatic coordination of surface traffic management activities with other ATC automation systems
- Full-scale, interactive tower simulator to realistically replicate busiest airline, air traffic control, and airport operations at NASA Ames Research Center

#### 1996 Projected Accomplishments:

- Complete prototype demonstration and validation.
- Activate full-scale, interactive tower/airfield simulator.

#### Project 021-200: Surface Movement Advisor (SMA)



#### 021-220 Multiple Runway Procedures Development

**P**urpose: This project will develop ATC procedures to reduce airport delays by more fully utilizing multiple-runway capacity during instrument meteorological conditions. This project will investigate the use of advanced surveillance techniques in conjunction with advanced avionics for reducing parallel runway spacing standards to less than 3,400 feet. Advanced sur-

veillance techniques include precision runway monitor (PRM) technology with electronically scanned antenna systems and high update rates. Air traffic procedures and flight standards criteria for simultaneous triple and quadruple instrument flight rules (IFR) parallel approaches will also be developed and validated. Requirements and techniques for improved surveillance and

navigation capabilities will be developed to support these procedures.

**Approach:** The FAA completed demonstrations of electronically scanned and "back-to-back" antenna PRM technologies resulting in acceptance of simultaneous, independent approaches to dual parallel runways spaced as closely as 3,400 feet. The PRM Program Office upgraded the Raleigh-Durham PRM system to commissionable status and is procuring additional PRM systems for five airports that satisfy the 3,400 feet spacing standard. Additionally, real-time simulations have shown the value of a final monitor aid, based on high-resolution color displays with a controller alert aid. These displays receive surveillance inputs from airport surveillance radar (ASR)-9 or mode select (Mode S) discrete addressable secondary radar system with data link, for monitoring parallel runway operations.

This project will conduct additional simulations and analyses to develop national standards and ATC procedures for parallel runways using PRM and final monitor aid technologies. Further research efforts on reducing runway spacing standards will focus on allowing approaches to parallel runways with less than 3,400 feet separation. The results of these studies for dual parallel runways will provide the basis for developing the spacing standards for closely spaced triple and quadruple parallel runways. This project will provide data and recommendations to the Air Traffic and Flight Standards Services for formulating standards and procedures.

**Related Projects:** Capital Investment Plan projects: A-11 Terminal Air Traffic Control Automation (TATCA), A-12 Airport Surface Target Identification System (ATIDS), F-14 System Support Laboratory Sustained Support, F-15 General Support Laboratory Sustained Support, and S-08 Precision Runway Monitor.

## Products:

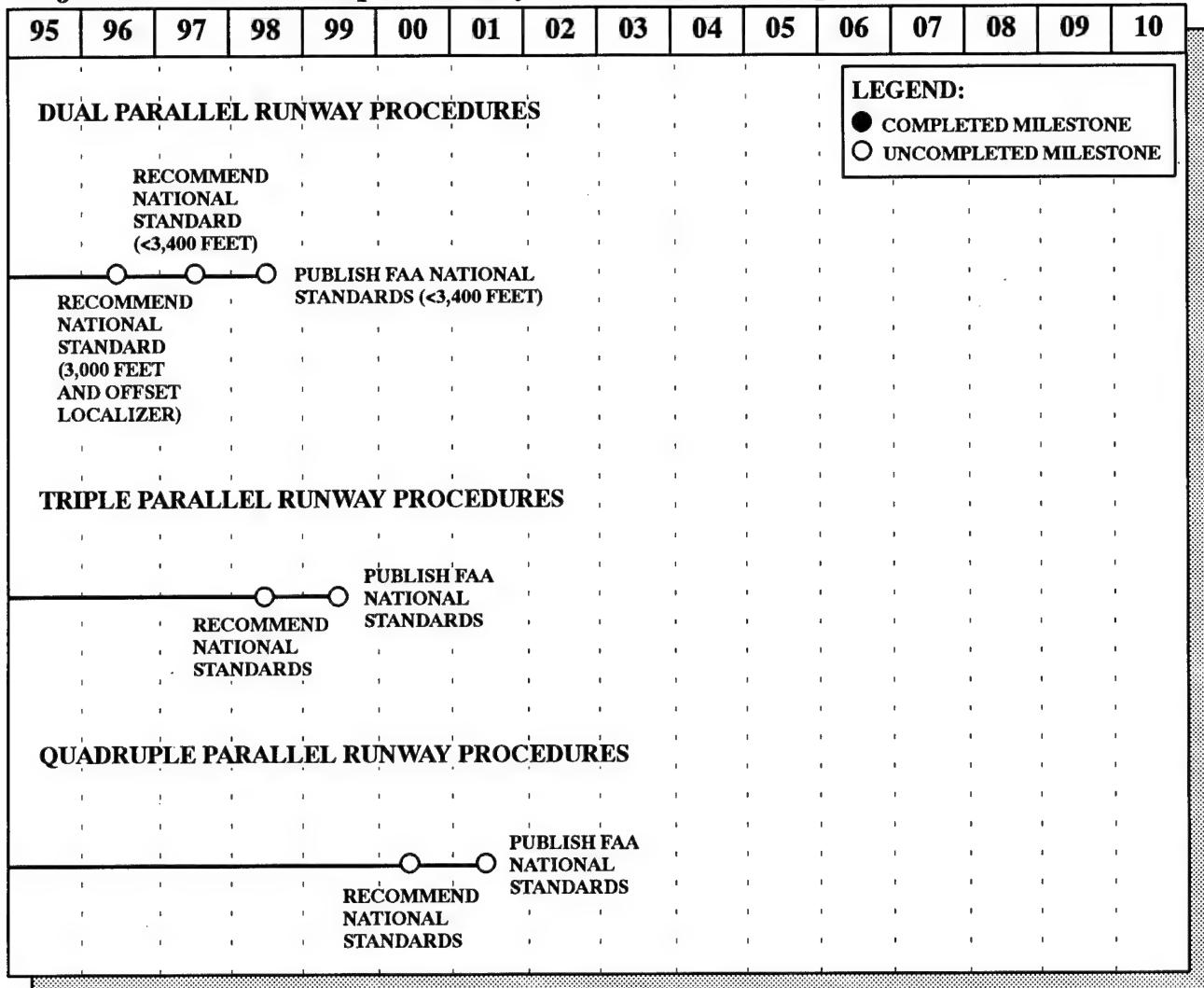
- Data and recommendations to develop approach standards for closely spaced dual, triple, and quadruple runways
- ATC simulation evaluations of IFR procedures for triple and quadruple parallel runways using existing and improved runway monitoring systems

## 1996 Projected Accomplishments:

- Recommend national standards for dual parallel runways with 3,000 feet spacing using the PRM and offset localizer.
- Develop recommendations for simultaneous triple parallel approach procedures using PRM for two selected airports.
- Complete enhancement to the collision risk model for parallel runways.

**Planned Activities:** In 1997, research will continue on the combined use of electronically scanned PRM technology and advanced techniques for possible further reduction of dual runway separation standards to less than 3,400 feet. Recommendations will be developed for approaches to quadruple parallel runways with 3,400 feet separation using PRM in 1998. Triple and quadruple standards for parallel runways will be accomplished in 1998 and 2000, based on the high-update surveillance system and advanced navigation/landing systems. FAA national standards for dual, triple, and quadruple parallel runways with the advanced surveillance system will be published in 1998, 1999, and 2001, respectively. Publishing these standards will satisfy the project's original purpose. Advanced techniques include potentially applying state-of-the-art autopilots, the global positioning system (GPS), and collision avoidance logic in controller displays to aid in the reduction of spacing between parallel runways.

## Project 021-220: Multiple Runway Procedures Development



## 021-230 Wake-Vortex Separation Standards

**P**urpose: Wake-vortices, particularly those generated by large transport aircraft, can present significant hazards to following aircraft in single runway operations. Parallel runway operations may also be severely affected by vortices which can propagate great distances while in ground effect. This project will focus on safely reducing separation standards leading to increased capacity in the terminal area. These

gains will be accomplished by understanding wake-vortex strength, duration, and transport characteristics, particularly as the vortices experience ground effect in the terminal environment. Potential methods to detect and avoid wake-vortices will be examined to enhance air-space use, decrease delays, and increase airport capacity in instrument meteorological conditions.

**Approach:** Current air traffic operations will be assessed to determine actual traffic spacing used under visual flight rules conditions. Vortex strength, decay, and transport characteristics, as well as the meteorological conditions that affect these characteristics, will be examined at selected, high traffic airports. Data from tower fly-by tests and other previously collected data will be combined with new data to provide a basis for reviewing existing separation standards and recommending modifications. Flight test simulations will be designed and conducted to determine if reducing the separation standards currently used under IFR conditions is feasible. Issues such as closely spaced parallel and converging runways, departure delays, and potential departure sequencing will also be explored through simulation.

Existing aircraft weight classifications will be reviewed, and a determination will be made as to whether the weight classifications and corresponding separations can be modified to improve single runway operations.

This project will include a joint effort with NASA to develop models and simulation techniques that characterize wake-vortex hazards. A memorandum of agreement was signed that commits the FAA and NASA to a joint research effort.

**Related Projects:** 024-110 Aviation System Capacity Planning and 042-110 Aeronautical Hazards Research. Capital Investment Plan projects: A-11 Terminal Air Traffic Control Automation (TATCA), F-15 General Support Laboratory Sustained Support, M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance, and W-07 Integrated Terminal Weather System (ITWS).

#### **Products:**

- Wake-vortex models/simulations
- Wake-vortex detection system
- Wake-vortex sensor requirements

#### **1996 Projected Accomplishments:**

- Develop wake-vortex transport and decay model in ground effect.
- Revise aircraft spacing/classification recommendations.
- Select sensor technology for further development.

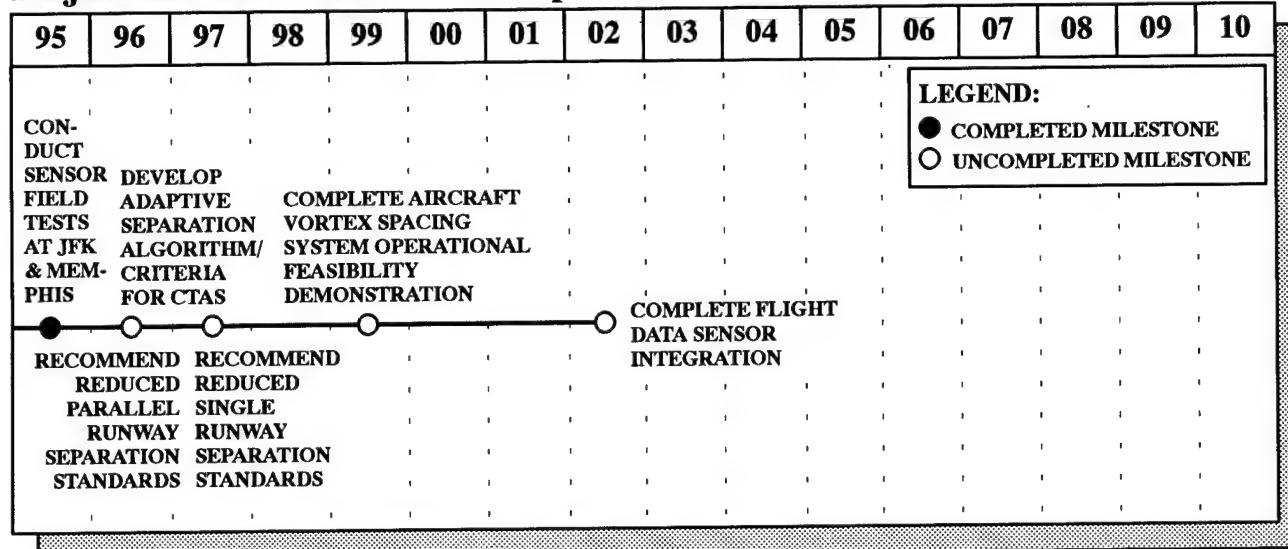
**Planned Activities:** Through 2001, this project will coordinate closely with NASA, industry, and the international community on wake-vortex research. NASA will continue through 1999 to develop models and simulation techniques that characterize wake-vortex hazards. Additionally, NASA research will be a key element in producing an effective wake-vortex sensor and aircraft vortex spacing system.

In 1997, development work will be completed on a wake-vortex detection system. This system will be used to validate wake-vortex transport and decay models. Also in 1997, long-term test and evaluation of the aircraft vortex spacing system by NASA will continue. The FAA will conduct field tests to address site-specific capacity concerns for near-term gains. In 1998, wake-vortex integrated detection and prediction systems will be validated, leading to an operational feasibility demonstration of the aircraft vortex spacing system in 1999. This system has the potential for increasing airport capacity even further. From 1999-2001, the aircraft vortex spacing system will undergo testing and refinement prior to operational implementation. Final implementation is expected in 2001, at which time the project will end.

- Recommendations on aircraft weight classifications
- Separation algorithms for TATCA based on leading/following aircraft types

In parallel with the standards/system development work, this project will develop a computer-based wake-vortex training program in 1996.

### Project 021-230: Wake-Vortex Separation Standards



### 022-110 Traffic Alert and Collision Avoidance System (TCAS)

**P**urpose: This project will develop, demonstrate, and assist in implementing an independent airborne collision avoidance capability to increase the safety and capacity of the National Airspace System. TCAS will increase safety by reducing midair collision risks. Capacity will be increased by using the improved cockpit display capability provided by TCAS to aid capacity enhancements such as simultaneous approaches to parallel runways and pilot-maintained in-trail spacing. The aviation community will be provided with standards and certification guidance materials required for implementing the system.

**Approach:** There are three TCAS versions: I, II, and IV, each with successively increasing capabilities. TCAS I is under evaluation through a limited implementation program (LIP). TCAS II operational implementation has been completed; however, development work on enhanced logic

changes will continue. TCAS IV development will continue through an LIP similar to TCAS I and II.

#### TCAS I

TCAS I generates traffic advisories to assist pilots in locating potential midair collision threats. The FAA has established a cost-shared contract with an avionics manufacturer to furnish TCAS I avionics for an LIP evaluation on several types of in-service commuter aircraft. This effort will provide operational and performance data on commercial TCAS I equipment in actual service.

#### TCAS II

TCAS II equipment, which includes a Mode S transponder, is intended for installation in transport category and high performance general

aviation aircraft. TCAS II equipment will not only provide traffic advisories but will also compute vertical-plane resolution advisories that indicate the direction the aircraft should maneuver to avoid collisions. To ensure that maneuvers from two TCAS-equipped aircraft do not conflict, resolution advisories are coordinated between aircraft using the integral Mode S transponder.

Through an LIP, an operational TCAS II evaluation has been carried out on a number of in-service airline aircraft. Federal Aviation Regulations now require that all airplanes with more than 30 passenger seats operating in U.S. airspace be equipped with TCAS II. Development efforts will continue to enhance TCAS II by resolving technical and operational issues associated with implementation.

#### TCAS IV

The TCAS III airborne antenna report confirmed that current state-of-the-art TCAS antennas would not support horizontal resolution advisories. Therefore, alternative approaches will be developed to provide a horizontal resolution advisory capability. The prime candidate is a GPS-based system using Mode S data link.

TCAS IV equipment, intended for installation in transport category aircraft, is designed to generate traffic advisories and resolution advisories in both the horizontal and vertical planes. Maneuvers will be coordinated between similarly equipped aircraft. The FAA is supporting minimum operational performance standards development for TCAS IV by an RTCA special committee.

In response to congressional direction, the FAA has developed a plan to complete the remaining development and test efforts, and evaluate the TCAS IV system on airline aircraft in an LIP. Completing the development program and the LIP for TCAS IV will enable the aviation community to implement the most advanced air-

borne collision avoidance system as a user option.

**Related Projects:** 024-110 Aviation System Capacity Planning and 031-110 Aeronautical Data Link Communications and Applications. Capital Investment Plan projects: F-15 General Support Laboratory Sustained Support, M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance, M-15 National Airspace System Spectrum Engineering Management, and S-02 Mode S.

#### **Products:**

##### TCAS I

- LIP -- Reports on the TCAS I avionics evaluation to provide industry with guidance for TCAS I certification and operation
- Installation of TCAS I on 10 to 30 seat turbine-powered commuter aircraft by December 31, 1995

##### TCAS II

- LIP -- Reports on TCAS II installation, certification, and operation on air carrier aircraft during routine operations
- TCAS II transition program report documenting TCAS II implementation program results and any required modifications
- TCAS II requirements document for certification in transport category aircraft
- ICAO standards and recommended practices that provide a basis for international certification and operational approval

##### TCAS IV

- RTCA minimum operational performance standards that define required performance under standard operating conditions

- System safety study assessing the overall safety characteristics associated with using the TCAS IV collision avoidance system
- LIP -- Report on TCAS IV installation, certification, and operation in air carrier aircraft

### 1996 Projected Accomplishments:

- Conduct TCAS II transition program.
- Complete TCAS IV surveillance subsystem design.

### Planned Activities:

#### TCAS I

The FAA will continue a multiyear transition program to assist aircraft operators with TCAS I implementation in the National Airspace System. The transition program will continue through 1998. Periodic transition program reports will provide guidance on installation, crew training, and system operation.

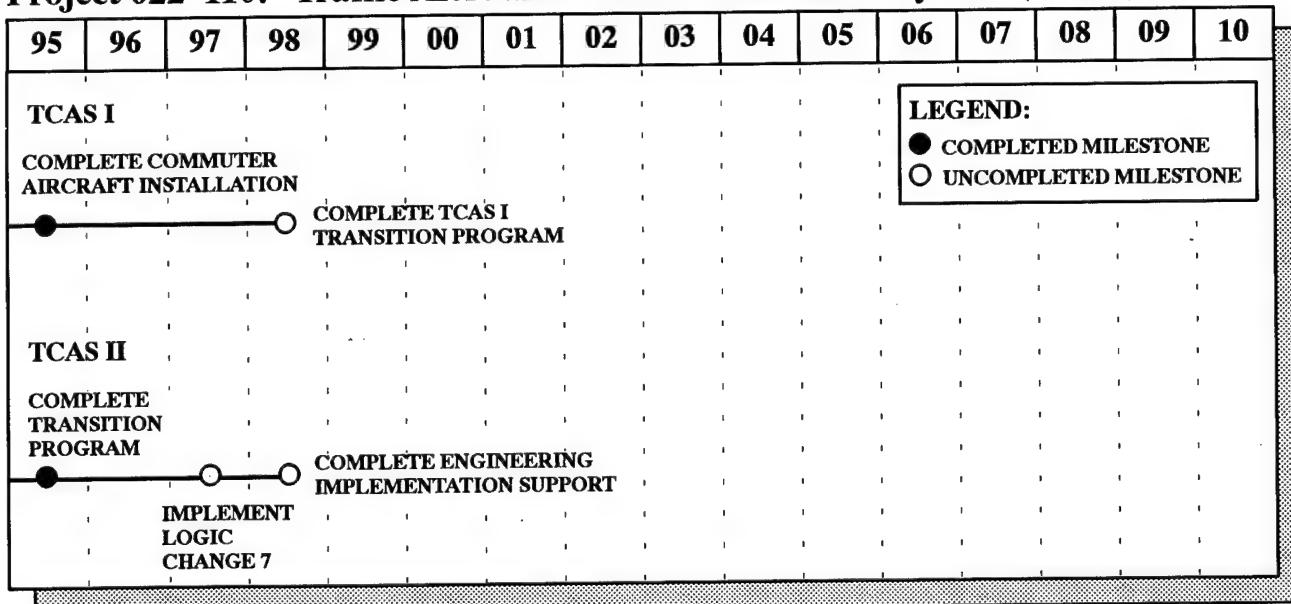
#### TCAS II

In accordance with Federal Aviation Regulations, all commercial aircraft with more than 30 passenger seats were required to be equipped with TCAS II by December 30, 1993. The FAA will continue to work with the aviation community to resolve technical and operational issues associated with TCAS II implementation. Development work will continue on logic change 7 until implementation in 1997. Engineering support will continue through 1998.

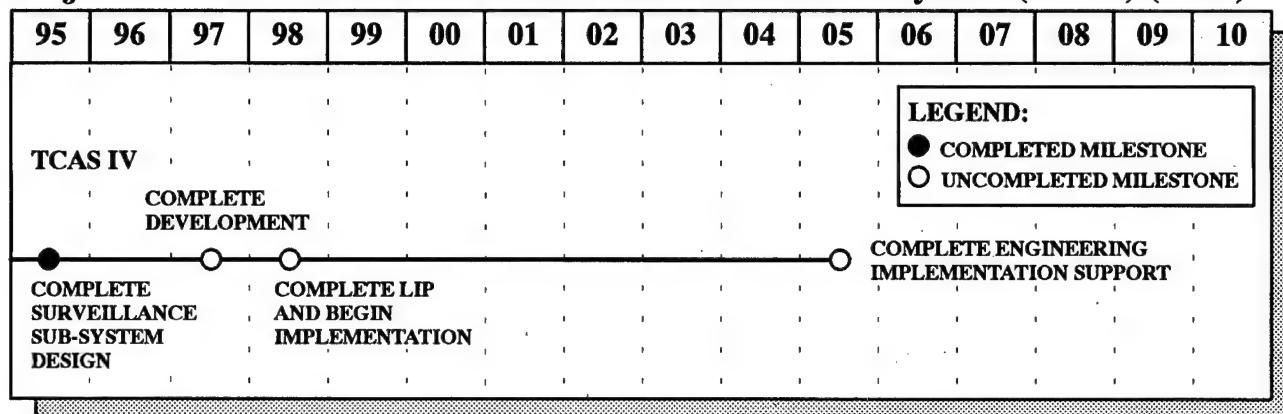
#### TCAS IV

Development of TCAS IV will be conducted through 1997. An LIP will be conducted in 1998 to determine the certification and operational requirements for TCAS IV. At the conclusion of the LIP in 1998, TCAS IV will be available for airline implementation. Engineering support, such as developing logic modifications to reduce unnecessary alert rates, will continue through 2005.

### Project 022-110: Traffic Alert and Collision Avoidance System (TCAS)



## Project 022-110: Traffic Alert and Collision Avoidance System (TCAS) (cont.)



## 022-140 General Aviation and Vertical Flight Program

**P**urpose: In response to the FAA's goal to revitalize the general aviation industry, this project will identify, initiate, and coordinate actions to facilitate introducing and expanding technology applicable to general aviation and vertical flight into the NAS. Research, engineering, and development efforts will focus on air traffic system design and advanced operational procedures; heliport/vertiport/intermodal design and planning; aircraft/aircrew certification, training, and human factors; and emerging technology applications.

The major portion of the general aviation element of this project is a collaborative NASA/FAA/industry technology program. The major objectives are to implement an economically viable short-haul transportation system to augment the existing national airspace system, stimulate the industry, and create jobs for airframe manufacturers, the propulsion industry, avionics shops, airports, and supporting industries. Research will include the rapid introduction of new cockpit display and control technologies; integrated ATC procedures; expert decisionmaking systems; enhanced airspace utilization; enhanced ground/cockpit information systems; and other technology initiatives.

**Approach:** Through the use of collaborative partnerships with industry, the General Aviation and Vertical Flight Office, in cooperation with other government agencies such as NASA and DOD will continue to produce short- and long-term research product initiatives to implement an advanced short-haul transportation system. This system will be designed in parallel with the evolving NAS architecture. A major focus of these research initiatives will be to educate and involve local communities early in the design phase.

The program will focus on the following technical subproject areas: air infrastructure, ground infrastructure, and aircraft/aircrew. Research in these areas, which emphasizes general aviation and vertical flight requirements, is designed to complement other R,E&D projects.

### Air Infrastructure

This subproject will provide research to enable reliable, all-weather operations for general aviation and vertical flight passenger and cargo aircraft. The research results will include developing nonprecision and precision GPS terminal instrument approach and departure procedures criteria; developing rotorcraft IFR approach and

departure ascent/descent angles; establishing low altitude communications, navigation, and surveillance for air traffic control services using GPS technology, multiple data links, and free flight functionality; and developing noise and emission reduction technologies.

### Ground Infrastructure

The ground infrastructure research will address airport, heliport, and vertiport design and planning issues, including the terminal area facilities and ground-based support systems that will be needed to implement safe and affordable, near all-weather, 24-hour flight operations. Developing obstacle avoidance capabilities, advanced approach lighting technologies, and an integrated graphical pre-flight planning system are critical design-related efforts. Research will include enhanced ground/cockpit information systems, noise abatement and emissions reduction, increased airport availability, and applying lessons learned from detailed accident/operations analyses.

### Aircraft/Aircrew

With the necessity for increased simulation use, this subproject will develop the criteria and guidance for simulators used for crew member training/evaluation. Training procedures will be established to reduce the human element causal factor in general aviation and vertical flight accidents.

Aircraft/aircrew research will: develop minimum performance criteria for visual scenes and motion-base simulators; evaluate state-of-the-art flight performance for cockpit design technology; develop improved training techniques to enhance decisionmaking reactions; and develop crew and aircraft performance standards for display and control integration requirements. Research will also be conducted to develop certification standards for both conventional and advanced technology aircraft.

**Related Projects:** 021-140 Oceanic Air Traffic Automation, 022-150 Flight Operations and Air Traffic Management Integration, 024-110 Aviation System Capacity Planning, 025-110 National Simulation Capability (NSC), 025-140 System Performance and Investment Analysis, 031-120 Satellite Communications Program, 032-110 Satellite Navigation Program, 051-130 Airport Safety Technology, 063-110 Propulsion and Fuel Systems, 064-110 Flight Safety/Atmospheric Hazards, 081-110 Flight Deck Human Factors, and 091-110 Environment and Energy. Capital Investment Plan projects: A-10 Oceanic Automation Program (OAP) and C-20 Aeronautical Data-link.

### **Products:**

- Nonprecision and precision GPS approach terminal instrument procedures criteria
- New cockpit technologies
- ATC route standards, procedures, and models
- Vertiport/heliport design standards
- Improved noise planning tools
- Vertical flight noise abatement procedures
- Aircrew training and certification requirements
- Cost/benefit assessments for deploying advanced aircraft technologies
- Civil Tiltrotor Development Advisory Committee final report to Congress
- Community Involvement Implementation Plan
- Atlanta Olympics short-haul transportation system demonstration

## **1996 Projected Accomplishments:**

- Conduct general aviation innovative aircraft design competition jointly with NASA.
- Establish air, ground, and training work packages for the NASA/FAA/industry advanced general aviation transport experiments (AGATE) project.
- Produce Category (CAT) I GPS precision approach terminal instrument procedures (TERPS) criteria for vertical flight aircraft.
- Demonstrate Atlanta Olympics short-haul transportation system.
- Complete phase one for establishing non-precision GPS approaches to all qualifying emergency medical facilities in the United States.

## **Planned Activities:**

### Air Infrastructure

In 1997, advanced rotorcraft precision GPS approach TERPS criteria will be developed and published. Also in 1997, low noise conversion corridor criteria for rotorcraft will be developed to support publishing terminal area IFR procedures for steep angle approaches and departures. Also, ATC and local controller training material related to noise abatement procedures will be published. The functional specification for the airborne communications, navigation, and surveillance avionics (CNS/A) will be completed. A report, based on the Atlanta Olympics demonstration, specifying design criteria for short-haul transportation systems and assessing community acceptance will also be published in 1997.

In 1998, test flights for the prototype AGATE aircraft will begin, with completion expected in 2000. Also in 1998, the CNS/A equipment will be placed into production, with implementation

expected in 1999. Therefore, decommissioning of selected components of the existing ground-based national airspace system may begin.

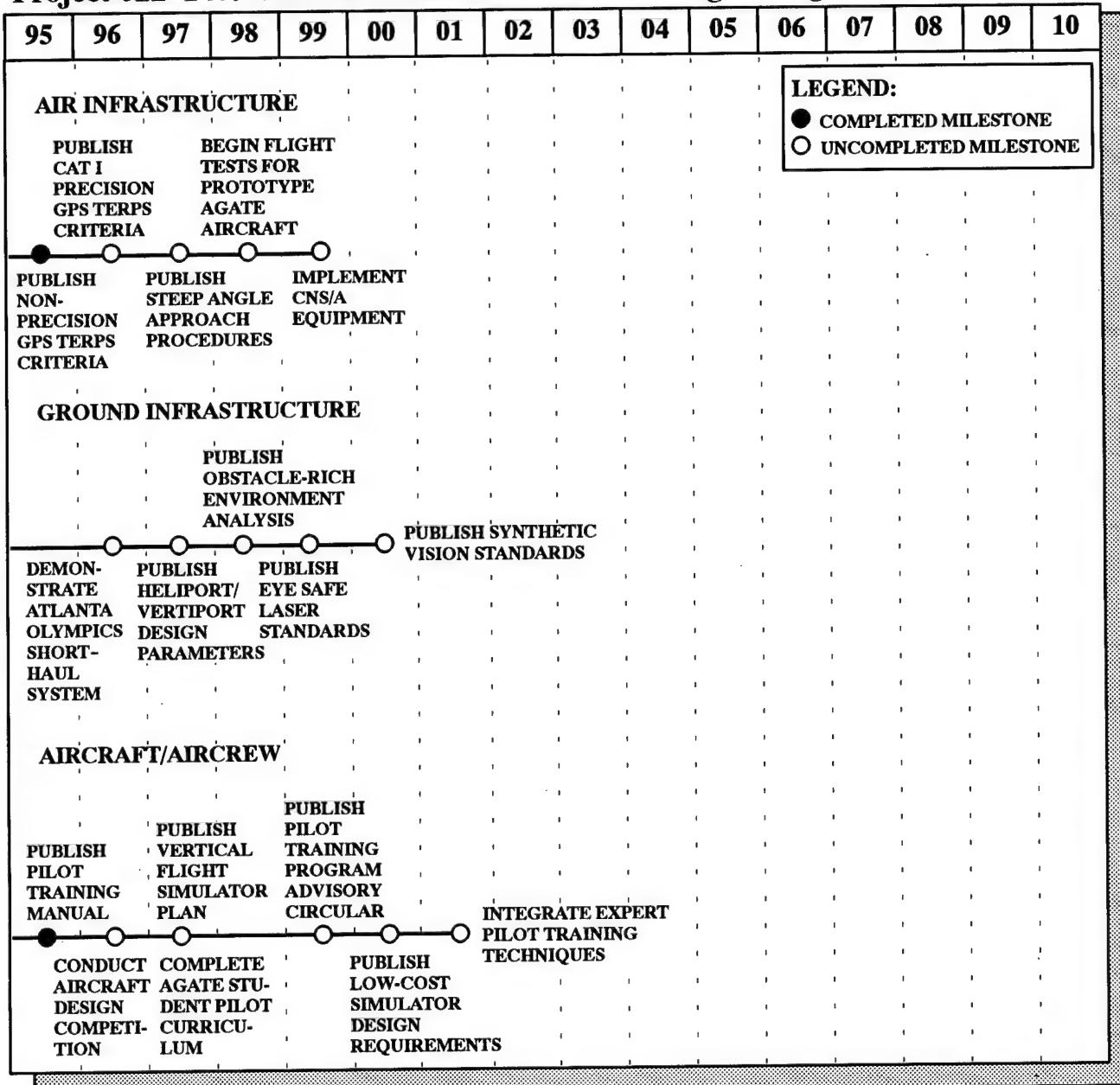
### Ground Infrastructure

In 1997, test results and analyses of heliport and vertiport design parameters will be published, including minimum required visual flight rules airspace needed for GPS curvilinear approaches and departures, minimum parking and maneuvering areas, marking and lighting, and rotor-wash protection requirements. Also in 1997, advanced pre-flight planning standards will be established. Low-cost, compact approach lighting criteria/standards for small community landing facilities will also be developed. A simulation-based analysis of pilot performance in an obstacle-rich environment will be published in 1998. Revisions to landing facility design parameters will also be published in 1998. Further research and development work is planned to develop heliport/vertiport standards for rotorcraft CAT III approaches in 1998; standards for eye-safe lasers in 1999; and standards for synthetic vision/infrared sensors in 2000.

### Aircraft/Aircrew

In 1997, the AGATE student pilot training curriculum will be completed. Also in 1997, the National Vertical Flight Simulator Plan for joint industry/local government advanced technology vertical flight demonstration program will be published. Interactive video and/or advanced simulation techniques on enhanced decisionmaking for pilot training will also be completed. In 1998, an instructor pilot training curriculum for AGATE aircraft will be established. In 1999, an advisory circular will be published and distributed to operators for assistance in establishing pilot training programs. In 2000, low cost simulator design requirements will be published along with simulation standards for approach procedure development. In 2001, the expert pilot training techniques will be integrated into training syllabi.

## Project 022-140: General Aviation and Vertical Flight Program



## 022-150 Flight Operations and Air Traffic Management Integration

**P**urpose: A cornerstone of the future air traffic management system will be direct information exchange between flight management system (FMS) computers and ground-based ATM computers via data link. Current FMS utilization in today's air traffic system environment

is estimated by the user community at approximately 30 percent. This underutilization has resulted in the need to better integrate the aircraft FMS with the ground ATM. This project will develop the capability to integrate flight management computer operations with ground-based air

traffic management automation. Integrating FMS and ATM operations via data link is expected to increase airspace capacity and ensure more efficient flight operations along more flexible, conflict-free routes.

**Approach:** Integrating FMS with ATM in the near term can be accomplished by adapting existing procedures to take advantage of FMS capabilities to save distance, fuel, and time on the aircraft side. On the ATM side, there will be a reduction in communications and associated workload. The goal for the future will be to increase currently perceived FMS utilization by a factor of three. This integration must encompass all operational areas where the FMS is used to gain overall system benefits. These areas include terminal, en route, and oceanic airspace as well as the airport surface.

This project will continue to support working groups such as the Industry/FAA Advanced FMS Applications Task Force. The task force is involved in creating new procedures using existing FMS capabilities for curved approaches and departures at selected airports. Procedures validation will be accomplished through data collection/analysis, simulation, and flight testing. These procedures will then be adapted to support FMS-guided terminal operations nationwide.

This project's primary focus will be developing and validating a set of functional and operational requirements for a next generation ATM-compatible FMS. These requirements will be used by industry to create standards for building the next generation FMS and retrofitting current technology aircraft. This work will be accomplished through a cooperative agreement between the FAA and industry. Work will also be done toward a lower cost aircraft system that will take advantage of current satellite technology to afford some of the air carrier ATM/FMS services to the regional airline and lower end general aviation community. An additional product will be developing FMS and FMS-like flight operations and

procedures that benefit from the new information exchange between the aircraft flight deck and the ground ATM system. These objectives will be accomplished by performing system engineering and analysis to integrate ground ATM automation systems with both the aircraft FMS and the airline operational control (AOC) centers in a synergistic three-way tie.

A key to successful FMS/ATM/AOC integration is developing automated communications among aircraft FMS, ground ATM, and AOC computers. This goal will be accomplished by developing a set of flight operations and air traffic management integration-specific data link operational requirements. These requirements will be included as part of an FAA/industry set of data link operational requirements that support air traffic and flight information services.

**Related Projects:** 021-110 Advanced Traffic Management System (ATMS), 021-140 Oceanic Air Traffic Automation, 022-140 General Aviation and Vertical Flight Program, 025-110 National Simulation Capability, and 031-110 Aeronautical Data Link Communications and Applications. Capital Investment Plan projects: A-01 En Route Automation Program, A-02 Tower Automation Program, A-05 Traffic Management System (TMS), A-11 Terminal Air Traffic Control Automation (TATCA), A-12 Airport Surface Target Identification System (ATIDS), and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- Flight operations procedures and standards for FMS-guided curved approaches and departures at selected airports
- Flight operations procedures and standards for FMS-guided terminal operations nationwide

- Flight operations procedures and standards for FMS-guided en route and oceanic operations
- Cost/benefit analysis report for ATM/FMS services
- Functional requirements document for the next generation ATM-compatible FMS
- Functional requirements document for next generation ATM-compatible reduced cost FMS-like avionics

#### **1996 Projected Accomplishments:**

- Complete cost/benefit analysis and report for ATM/FMS services.
- Complete simulation and validation testing of ATM/FMS services.
- Develop procedures and standards for ATM/FMS services.
- Complete Advisory Circular, AC120. Communications/Navigation/Surveillance.

**Planned Activities:** In 1997, analyses will be completed to support nationwide standards for FMS-guided terminal operations with implementation by 1998.

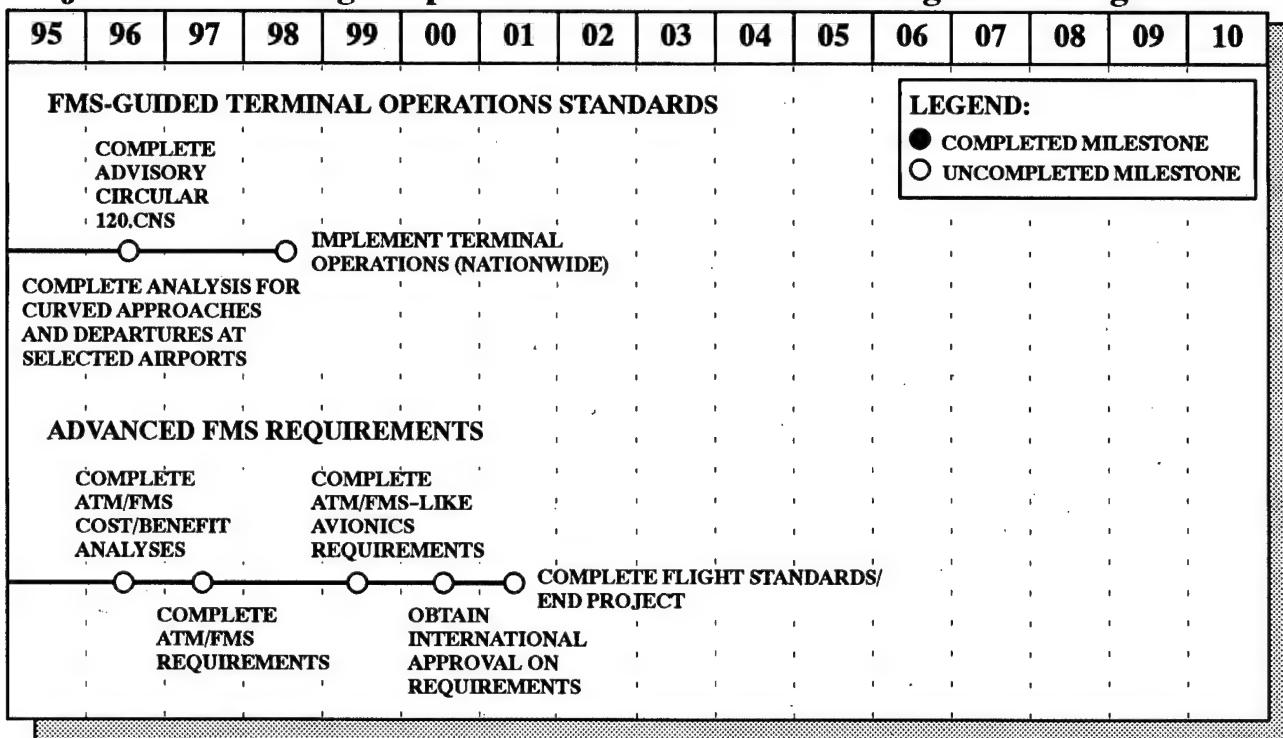
In 1997-1998, further simulation experiments involving flight operations and air traffic management scenarios will be conducted. Procedure validation will be conducted in parallel to simulations, and will be completed by 2000. Flight standards and guidance material will be completed in 2001.

An activity will continue to develop a functional requirements document by 1997 for advanced FMS capabilities to ensure full integration of flight management and ATM operations. In 1998, work will begin on obtaining international agreement on the ATM-compatible FMS requirements document by 2000.

Efforts will continue toward development of a functional requirements document for next generation ATM-compatible reduced cost FMS-like avionics by 1999.

This project is projected to end in 2001 when the FMS requirements are developed and if the ATM-compatible FMS requirements document receives international approval.

## Project 022-150: Flight Operations and Air Traffic Management Integration



## 023-120 Separation Standards

**P**urpose: This project will provide quantitative guidance for domestic and international efforts to establish minimum vertical and horizontal separation standards. The ability to increase system capacity is directly related to separation standards. As new technology is introduced, separation standards will be reduced, resulting in increased system capacity. Another benefit will be significant improvements in fuel efficiency from flying more optimum flight profiles.

**Approach:** Tests will be conducted to provide quantitative guidance for determining domestic and oceanic separation minima permissible as new technologies are introduced. This effort will establish separation minima based on improved navigation, automatic dependent surveillance, other new technologies, and ATC improvements.

This project will analyze separation standards in the North Atlantic, South Pacific, Central East Pacific, North Pacific, and Western Atlantic Route Systems airspace. The project will examine the impact of various system improvements on horizontal and vertical separation. Time-based navigation capabilities and associated ATC procedures will be analyzed to determine whether time-based longitudinal separation standards or distance-based standards are more appropriate. An assessment of when free flight can be safely supported with planned technologies and procedures will be developed.

**Related Projects:** 021-140 Oceanic Air Traffic Automation, 025-110 National Simulation Capability (NSC), 027-110 Automation System Assessment, 031-110 Aeronautical Data Link Communications and Applications, 031-120

Satellite Communications Program, and 032-110 Satellite Navigation Program. Capital Investment Plan projects: A-10 Oceanic Automation Program (OAP), F-15 General Support Laboratory Sustained Support, and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- Reports on reduced horizontal oceanic separation feasibility
- Report on domestic and international general guidance material for establishing separation standard minima
- Data packages for coordinating international horizontal oceanic separation standards
- Reduced vertical separation data analyses, operational tests, and evaluations
- Rulemaking to enable reduced separation standards

#### **1996 Projected Accomplishments:**

- Conduct reduced vertical separation verification flight trials in the North Atlantic.
- Conduct flight trials of 50 nautical mile lateral and 50 nautical mile (seven minute) longitudinal separation for future air navigation system (FANS) 1 aircraft in the South Pacific.
- Revise the collision risk model assessing the combined effects on aircraft separation of automatic dependent surveillance, global positioning system navigation, and controller pilot data link communication.

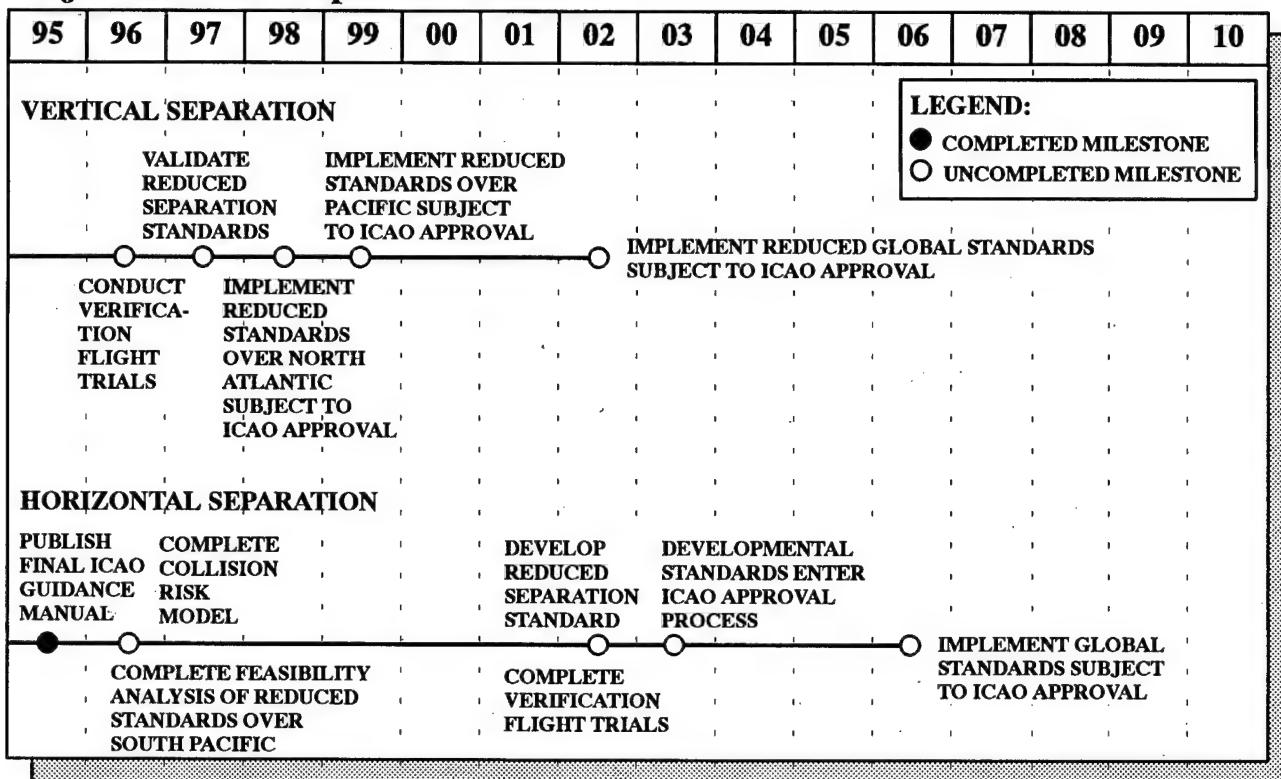
**Planned Activities:** The North Atlantic Systems Planning Group will continue planning for verti-

cal separation reduction over the North Atlantic. In 1997, flight trials will be conducted with the reduced separation standard of 1,000 feet vertical above flight level 290 in the North Atlantic. In 1998, ICAO approval is expected for implementing reduced standards in the North Atlantic. Planning will continue for vertical separation standards reduction in Pacific airspace with possible implementation by 1999, subject to ICAO regional approval. Additional regional analyses will be conducted through 2001 to support the FAA's goal of having a global oceanic vertical separation standard. The analyses will determine if certain oceanic regions will require a deviation from a global standard or if a global standard will suffice for all areas. ICAO approval on a global standard is expected by 2002.

In 1997, operational trials will be conducted for 50 nautical miles lateral/50 nautical miles longitudinal separation for FANS 1-equipped aircraft in the North Pacific. Also in 1997, a feasibility demonstration will be conducted for 30 nautical miles lateral/30 nautical miles longitudinal separation for FANS 1-equipped aircraft in the South Pacific.

From 1998-2002, additional verification flight trials and analyses will be conducted in other oceanic regions to develop a global standard that reduces horizontal separation to 30 miles. As technology advances and regional traffic increases, analyses and operational trials will be conducted on a 15 nautical mile separation standard. In 2003, this developmental standard will enter the ICAO approval process to develop a worldwide standard by 2006. The FAA's goal is to eventually reduce oceanic horizontal separation standards to near-domestic limits (approximately 5 miles). Research to meet this goal will be undertaken where there is both a demand and an economic benefit.

## Project 023-120: Separation Standards



## 024-110 Aviation System Capacity Planning

**Purpose:** Twenty-two major metropolitan airports currently experience over 20,000 hours of annual delay due to capacity restraints. As the aviation industry continues to grow, the number of affected airports will increase, with projections showing 33 experiencing 20,000 hours of delay by 2003. This project supports development of an overall capacity strategy, the conduct, measurement, and assessment of airports and technologies, and development and application of electronic tools that aid in the formulation of that strategy. These initiatives can be implemented to increase the number of operations per hour, reduce delays, and increase savings through lower maintenance/operating costs. This project complies with the Congressional mandate for producing airport improvement plans, responds to the aviation industry high

priority initiatives for increased capacity, and responds to recommendations from the Presidential Commission on Improved Airline Competitiveness.

**Approach:** A primary focus of this project is responding to near-term airport-driven capacity issues. As traffic demand at airports changes, research efforts are reallocated to meet the changing priorities. This dynamic environment is driven by constantly changing airline needs. Airport, airspace, tactical initiative, and capacity design teams currently active at 15 airports are comprised of airport operators, airlines, other users, and FAA representatives. Each team starts with a current airport and/or adjacent airspace environment simulation using actual operating data to establish a baseline. The team then develops a list

of potential improvements to increase capacity and reduce delays by using a variety of simulation and queuing models, and tests their effect in the specific airport environment. Among the improvements investigated are airfield improvements such as new runways and runway extensions; improved approach procedures; and new facilities and equipment such as the precision runway monitor. Those improvements found to produce the greatest capacity increases, together with the estimated delay reductions and cost savings, are described and recommended for implementation in the final design team plans.

Design teams also address airspace structure and develop new designs and traffic flow modifications to accommodate more aircraft within the terminal airspace. Airspace redesign begins with simulating the air traffic control center airway environment using operational data to establish the baseline. The airspace design team then develops alternatives such as more direct routings; segregating jet, turboprop, and piston engine traffic; and relocating cornerpost navigational aids to allow for more arrival and departure routes. These alternatives are simulated to determine their effect on delay, travel time, sector loading, and aircraft operating cost. The most successful alternatives are then incorporated into a plan to redesign the airspace for increased capacity.

The Tactical Initiatives Team project, on the other hand, works to develop achievable, near-term solutions for chronic delay airports by focusing on resources under FAA control. This program is limited to initiatives that will produce results within 2 years.

**Related Projects:** 021-220 Multiple Runway Procedures Development, 021-230 Wake Vortex Separation Standards, 022-110 Traffic Alert and Collision Avoidance System (TCAS), 025-130 Air Traffic Models and Evaluation Tools, and 091-110 Environment and Energy. Capital Investment Plan projects: F-15 General Support Laboratory Sustained Support and M-03 Capital

Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- Aviation Capacity Enhancement Plan
- Airport Capacity Design Team Plans
- Airspace Analysis Technical Plans
- Aviation Capacity Initiatives Report
- Aviation System Capacity Enhancement video
- Terminal Airspace Capacity Design Team Plans
- Tactical Initiatives Reports
- Aviation System Capacity Annual Report
- Regional Design Team Reports

#### **1996 Projected Accomplishments:**

- Develop improved independent converging approach procedures and standards.
- Produce 1996 Aviation Capacity Enhancement Plan.
- Complete Airport Capacity Design Team plans for Atlanta, Memphis, Detroit, San Jose, and Portland.
- Complete Airspace Analysis Technical Plans.
- Complete Tactical Initiatives Report for Dallas-Fort Worth, Reno, Miami, Boston, and Charlotte.
- Complete airspace analyses at Los Angeles (Phase II) and Dallas-Fort Worth ARTCC's.

- Complete Terminal Airspace Capacity Design Team plans at Salt Lake City, Tampa, and Minneapolis.
- Complete GPS simulation procedures for Air Traffic to determine benefits for air carriers, corporate aircraft, and general aviation due to early equipage of GPS.
- Complete International Tactical Initiatives at Schiphol International Airport, Netherlands and Seoul International Airport, Seoul, South Korea.

**Planned Activities:** Airport Capacity Design Team efforts will continue at New York (JFK, LGA, and EWR), San Francisco (SFO, OAK, and SJC), Chicago, Denver, Memphis, and Detroit. The sequence of events is to conduct a study lasting approximately 12 to 18 months at each airport, followed by capacity improvement recommendations. These teams will develop Airport Capacity Design Plans for each airport by 1997.

In 1997, Airspace Analysis Technical Plans will be developed for Albuquerque, Boston, and Memphis ARTCC's. These plans will lead to airspace redesigns at these locations to improve traffic flows. The sequence of events is to study these

airspaces for 2 years and then issue recommendations for capacity enhancements.

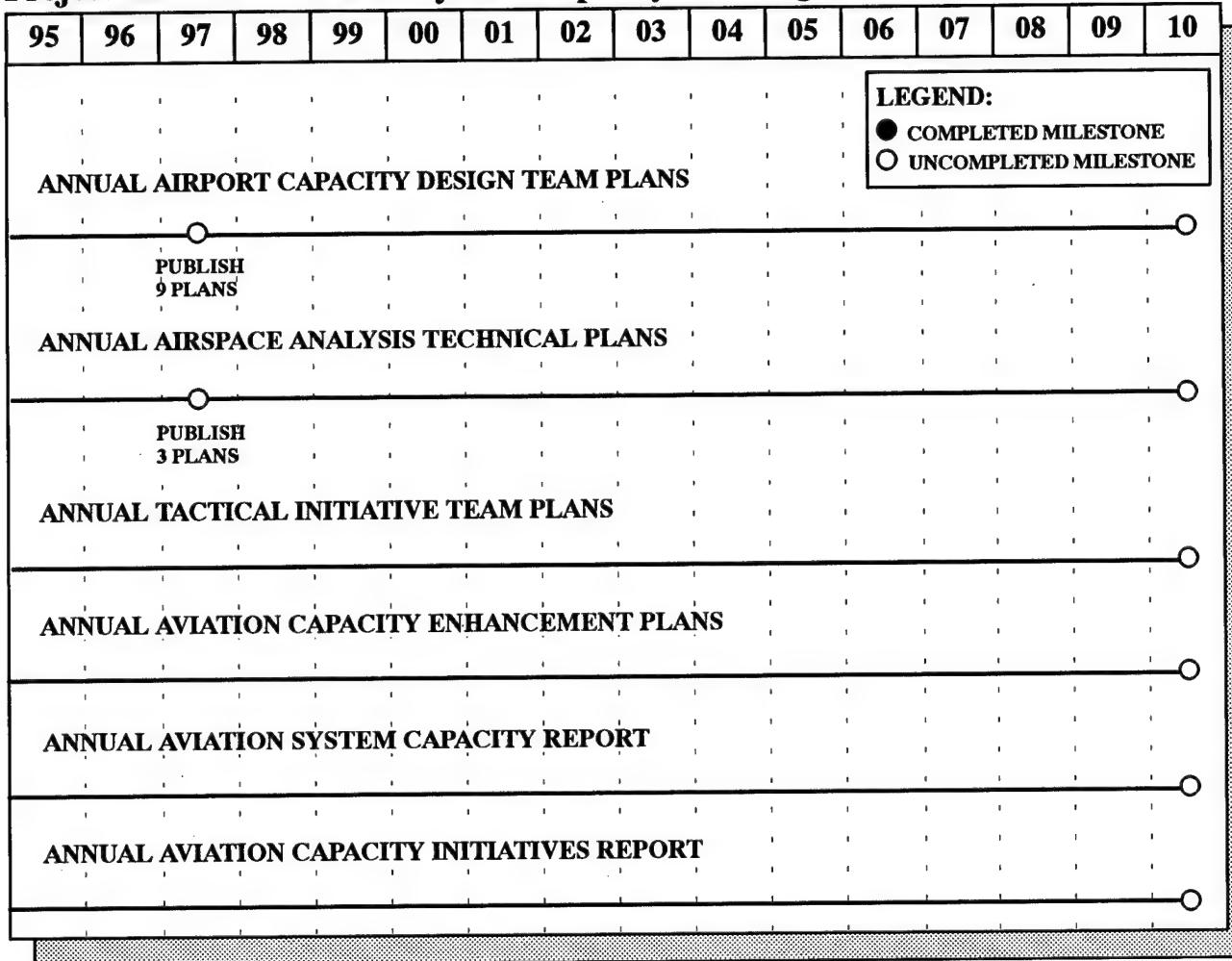
From 1997 to 1999, simulations and flight demonstrations will be conducted to determine if the surveillance capabilities of TCAS can be expanded for separation assistance. A cockpit display of traffic information will play a vital role in the free flight concept. It will also be important in improving departure and arrival spacing, wake vortex avoidance, and enhanced non-radar applications. The FAA Strategic Plan goals include improved system efficiency, a reduction in controller workload, and enhanced safety.

In 1997, the Tactical Initiatives Team will investigate near-term solutions to capacity problems at airports experiencing chronic delays or undergoing major reconstruction projects. As technology evolves, the Tactical Initiatives Teams will continually analyze delay problems and develop new, near-term solutions.

In 1997, the Terminal Airspace Capacity Design Team will complete the capacity plans for Charlotte, Orlando, Cincinnati, and St. Louis.

The following documents will be produced annually: the Aviation Capacity Enhancement Plan, the Aviation System Capacity Annual Report, and the Aviation Capacity Initiatives Report.

## Project 024-110: Aviation System Capacity Planning



## 025-110 National Simulation Capability (NSC)

**P**urpose: The NSC will aid and support the R,E&D and systems engineering missions of the FAA by integrating the various R,E&D program elements across the NAS environment. The capability to integrate future ATC subsystems during the conceptual stage of a project permits early requirements validation, problem identification, solution development for those problems, and system capability demonstrations. It permits early injection of human factors and system user inputs in the concept formulation process. The net result is reduced risk in developing products

for the National Airspace System, faster infusion of new technology, early acceptance of new NAS concepts by system users, and greater efficiency in performing the R,E&D and systems engineering missions.

**Approach:** The NSC will be a unique capability because it will not exist in any one place but will be achieved by linking together, on a distributed interactive network, existing simulation capabilities. That capability will allow the FAA to horizontally integrate components of future ATC

systems and assess their suitability and capability before production investment decisions are made. Horizontal integration will bring together diverse system components such as terminal automation, en route automation, oceanic control, aircraft flight management systems, and mixes of aircraft types and performance in a flexible, interchangeable, and dynamic simulation environment. The NSC will permit evaluating new operational concepts, human interfaces, and failure modes in a realistic, real-time interactive ATC environment capable of simulating new or modified systems at forecast traffic levels. Simulation capabilities will be expanded by interfacing with various remote research centers that possess nationally unique facilities and expertise.

**Related Projects:** 021-140 Oceanic Air Traffic Automation, 022-140 General Aviation and Vertical Flight Program, 022-150 Flight Operations and Air Traffic Management Integration, 023-120 Separation Standards, 025-130 Air Traffic Models and Evaluation Tools, 025-140 System Performance and Investment Analysis, and 084-110 Flight Deck/ATC System Integration. Capital Investment Plan projects: A-01 En Route Automation Program, F-14 System Support Laboratory Sustained Support, F-15 General Support Laboratory Sustained Support, F-16 FAA Technical Center Building and Plant Support, and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- NSC documentation including: NSC Operating Plan, NSC Configuration Management Plan, NSC Strategic Plan, and the NSC Business Plan
- Experiment plans and reports

- Air traffic control simulation protocol and associated infrastructure development plans

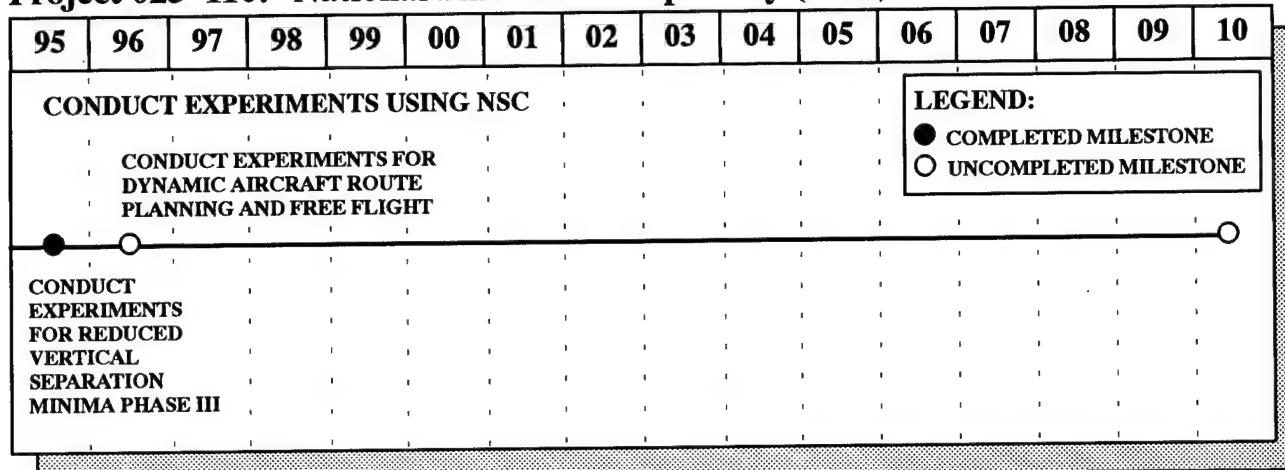
#### **1996 Projected Accomplishments:**

- Complete reduced vertical separation minima phase III simulation.
- Complete dynamic aircraft route planning phase II simulation.
- Complete first phase of free flight prototyping and simulation activities (both ground and airborne situational awareness of safety initiative).
- Complete air traffic control simulation protocol.
- Complete integration of EuroControl Experimental Center and the French Centre D'Etudes de la Navigation Aerienne ATC facilities.
- Complete pre-simulation shared data base for site, scenario, and weather data for use by the entire aviation community.

**Planned Activities:** NSC will continue to support developing expanded experimentation capability that will be responsive to FAA sponsor organization requirements. New experiments will be conducted that take full advantage of the additional NSC functionality.

As more issues are identified, experiments will be developed and conducted in the NSC during the out years.

## Project 025-110: National Simulation Capability (NSC)



## 025-130 Air Traffic Models and Evaluation Tools

**P**urpose: This project will produce modeling and analytic tools to support operational improvements, airspace and airport design, environmental analysis, investment decisionmaking, and ATC system design analysis. The products from this project will provide ATC with the ability to plan, evaluate, and update operational changes rapidly to accommodate the more dynamic airport/airspace environment. This project's models will respond to changing operational concepts, such as free flight, resulting from the improvements to satellite navigation, communications, and increased ATC and cockpit automation. The program will emphasize improvements to existing models and new model developments that produce the highest payoff. Modeling products will be improved to make them simpler, faster, more effective, and more widely used and accepted.

**Approach:** Development will focus on integrated airport and airspace modeling. Previously developed models, such as National Airspace System performance analysis capability (NASPAC) and the FAA's airport and airspace simulation model (SIMMOD), will be made

easier, faster, and more flexible to use. New model variants will enable clients to make fast approximations to complex situations. SIMMOD, an FAA trademark software program, is used by the FAA, industry, and foreign governments to design airport layouts and airspace routings.

The sector design analysis tool (SDAT) aids in redesigning en route airspace to increase capacity and balance the controller workload. SDAT derivatives are the terminal airspace sector design analysis tool (T-SDAT) and the regional airspace sector design analysis tool (R-SDAT) that provide new capabilities for evaluating terminal and multicenter en route airspace design. Additionally, a critical sector detector will be developed to determine when airspace sectors will reach critical traffic density levels based on controller workload limits.

A software representation of free flight will identify the data flow and process required in the free flight concept. This representation will provide a capability to review current and developmental hardware programs against free flight

requirements. Analysis and development of algorithms to support free flight will be conducted. These analyses will include developing advanced conflict probes to maintain safe separation of aircraft and tools to measure dynamic traffic density.

**Related Projects:** 024-110 Aviation System Capacity Planning, 025-110 National Simulation Capability (NSC), 025-140 System Performance and Investment Analysis, and 091-110 Environment and Energy. Capital Investment Plan projects: A-05 Traffic Management System (TMS) and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- Enhanced SIMMOD airport and airspace simulation model
- SIMMOD/SDAT/NASPAC capabilities installed in selected ARTCC's, TRACON's, and FAA regional offices
- NASPAC U.S. airspace simulation production model
- SDAT, T-SDAT, and R-SDAT
- Critical sector detector
- Dynamic traffic density tool
- Advanced conflict probe algorithms

#### **1996 Projected Accomplishments:**

- Incorporate Eurocontrol's reorganized mathematical air traffic control simulator (RAMS) into SIMMOD 3.

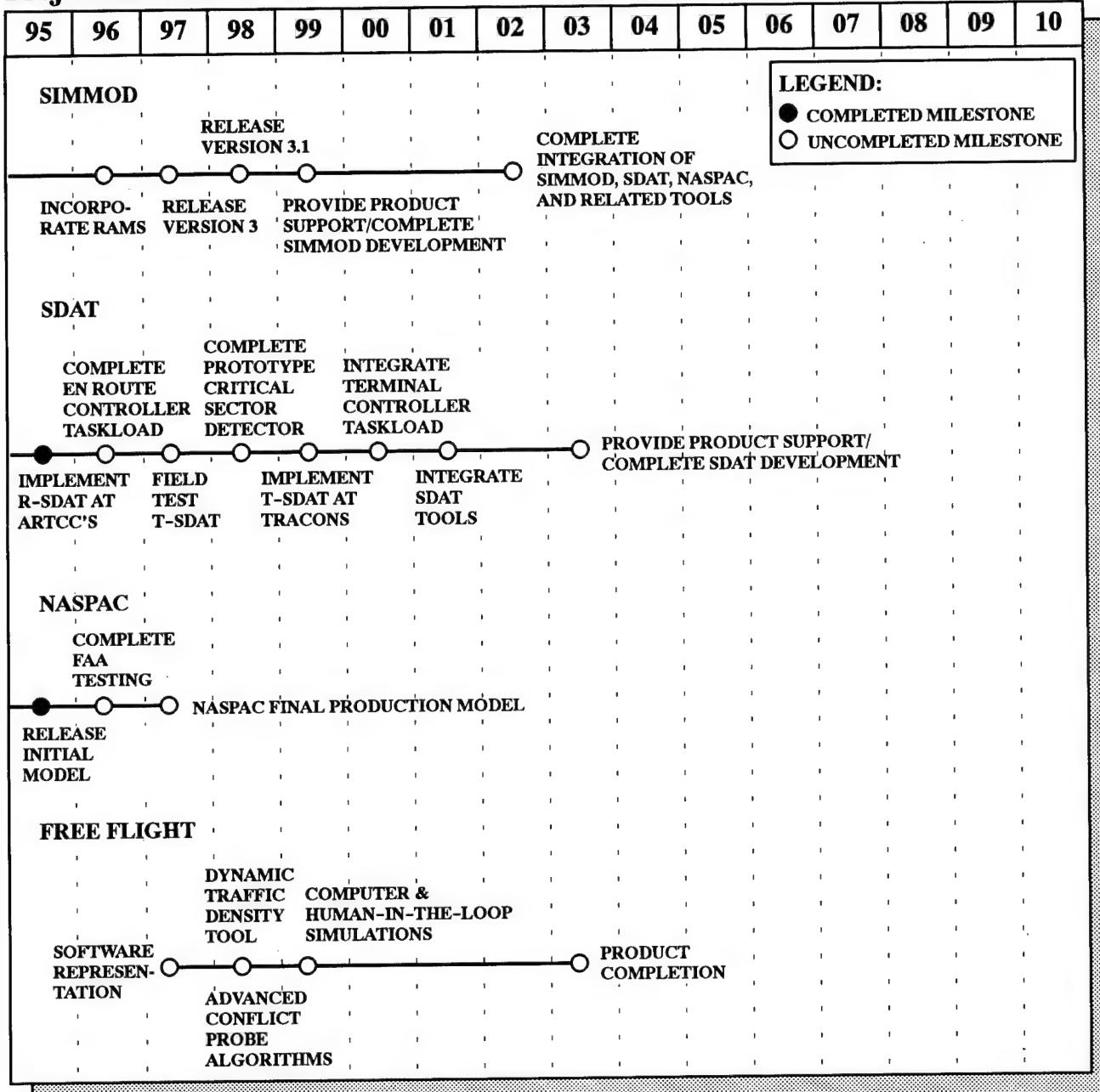
- Complete prototype T-SDAT.
- Complete en route controller taskload in SDAT.
- Complete final version of NASPAC.

**Planned Activities:** New SIMMOD logic enhancements will increase simulated traffic dynamic control and account for en route system dislocations. In 1997, a new SIMMOD, version 3, will be released to accommodate future airspace requirements for user-preferred direct routing. In 1998, version 3.1 with controller communications modeling capability will be released. This project will provide SIMMOD product support through 1999 to complete SIMMOD development.

T-SDAT will be field tested in 1997, and a prototype critical sector detector will be completed in 1998. In 1999, T-SDAT will be implemented at TRACONS. The terminal controller taskload tool will be integrated in 2000, with final integration of SDAT tools expected in 2001. Product support will be provided through 2003 when SDAT development will be completed. NASPAC testing will be completed and a production model delivered in 1997. Integration of existing tools with the FAA's integrated noise model, optimal route tool, and advanced fuel-burn models will be completed in 2001.

In 1997, a software representation of the free flight concept will be completed. In 1998, a dynamic traffic density tool and an advanced conflict probe algorithm will be completed. Computer and human-in-the-loop simulations will be conducted in 1999 to further define the free flight concept. Expected completion date for this project is 2003.

## Project 025-130: Air Traffic Models and Evaluation Tools



## 025-140 System Performance and Investment Analysis

**P**urpose: Currently, the FAA has an incomplete capability for determining what R,E&D investments are needed to produce early benefits for the aviation community. An analysis capability is needed to more fully understand present and future problems in the context of the

overall air traffic management system. Each individual R,E&D project has a narrow focus in an attempt to solve a specific issue or problem. This project will analyze individual R,E&D projects to determine their NAS impact from a broad perspective. Information and data from this

research will be used to help guide planning for R,E&D investments. For example, this project will anticipate: airport, airspace, airway facility, and other needs for improving operating efficiencies, as well as minimizing noise and safety concerns.

**Approach:** This project will apply models and analysis tools to develop the operational NAS baselines, conduct analyses, and provide the quantitative findings necessary for supporting/guiding R,E&D program investment decisions. State-of-the-art operations research methodologies will be used to study the dynamics and inter-relationships of the NAS to define those new technologies/concepts that will have the greatest value for the aviation community. These methodologies include using mathematical models, simulations, statistical analyses, and investment analyses. This project will use the latest aviation community tools available to the FAA, other government agencies, the private sector, and academia. In particular, this project will use models and tools developed by project 025-130, Air Traffic Models and Evaluation Tools. The hallmark of this analysis capability is to provide proactive and timely findings to help resolve critical R,E&D issues. This project will work closely with other organizations, such as Air Traffic, System Capacity, and Aviation Research to complement other R,E&D projects and facilitate information transfer.

**Related Projects:** 021-200 Surface Movement Advisor, 022-140 General Aviation and Vertical Flight Program, 024-110 Aviation System Capacity Planning, 025-110 National Simulation Capability, 025-130 Air Traffic Models and Evaluation Tools, and 027-110 Automation System Assessment. Capital Investment Plan projects: M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- Annual program plan

- Annual NAS performance baselines
- Reports/findings on current and future NAS performance
- Reports on airspace and airport operational analyses
- Reports/findings on R,E&D project NAS operational effectiveness
- R,E&D project and process investment analyses
- Performance bulletin providing guidance on using each analysis' results for improving operation and investments

#### **1996 Projected Accomplishments:**

- Publish report and performance bulletin on a modified future baseline of the national air-space system.
- Publish report and performance bulletin on an assessment of the anticipated air traffic control system for 2006.
- Complete two reports with findings on using GPS for more efficient routing in the NAS.
- Complete evaluation of advanced separation standards on NAS performance and safety.
- Conduct investment analyses of the 1998 R,E&D program and selected projects.

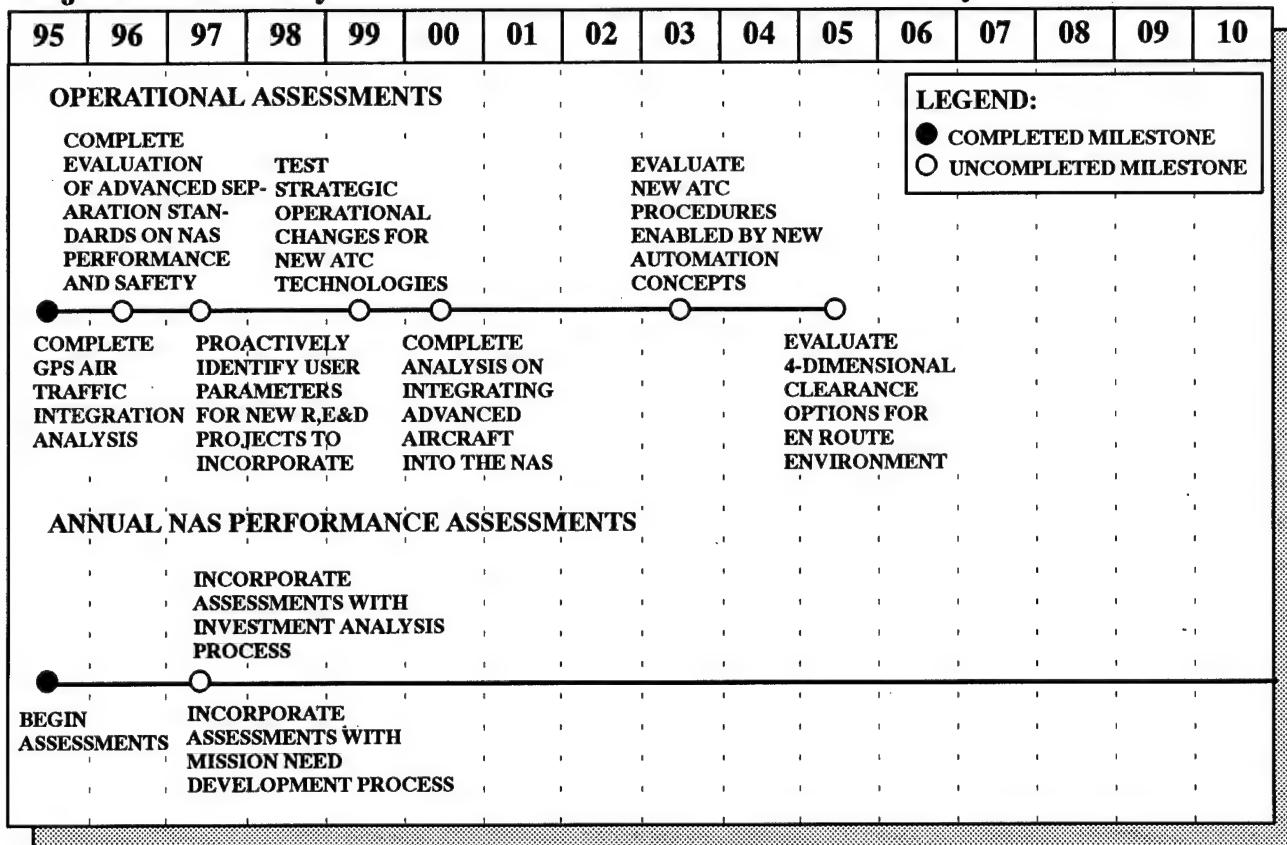
**Planned Activities:** A key product of this project is a yearly NAS performance assessment. The assessment's objective is to maintain an up-to-date NAS performance appraisal used to construct guidance for new R,E&D projects. In 1997 and beyond, this project will broaden the operational focus of the analyses to include aviation research investments, airway facilities,

system capacity, and flight standards issues. In 1997, operational assessments will be conducted to proactively identify user parameters that new R,E&D projects will incorporate. These parameters will ensure that R,E&D projects are sensitive to the aviation industry's economic health. Also in 1997, NAS performance assessments will be integrated with the R,E&D mission need development process and the investment analysis process.

In 1998 and beyond, operational assessments will identify critical operational changes that may be required to realize maximum benefits from new R,E&D projects. In 1999, strategic operational

changes for new ATC technologies will be tested and the findings delivered to appropriate agencies. In 2000, an analysis will be completed on integrating advanced aircraft into the NAS. Examples of these new aircraft are the high-speed civil transport and 600-800 passenger ultra-large aircraft. In 2003, this project will evaluate new ATC procedures resulting from new automation concepts for strategic air traffic management. In 2005, 4-dimensional clearance options will be evaluated for the en route environment. The findings generated by these evaluations will be provided to appropriate regulatory agencies for implementation.

### Project 025-140: System Performance and Investment Analysis



## 027-110 Automation System Assessment

**P**urpose: Adequate tools are not currently available to determine how automation system design alternatives affect NAS performance. This project will develop and employ benefit assessment tools to provide valid evaluations of the relative benefits of proposed automation systems and automation system design parameters. These tools will allow rational assignment of R,E&D priorities, selection of lower cost system parameters, and maximization of benefits derived from automation investments.

The higher-level assessments provided in other R,E&D projects, due to their broad perspective, are not intended to provide the timely and detailed analyses necessary to assess automation design alternatives. This project specifically will identify cause-and-effect relationships in sufficient detail to discriminate between automation alternatives, set key system parameters, and assess impacts and opportunities arising from the introduction of new operational capabilities. Data and software from this project will be made available to support the detailed design engineering analysis efforts within each automation domain as well as higher-level assessments.

**Approach:** The project will develop a capability to extract useful relationships and trends from existing and newly identified industry flight delay data. All potential sources of data will be examined and alternate data collection and processing methods will be defined. This data will then be used to perform studies and analyses to identify benefits of specific automation innovations or the impact of system design and parameter changes.

Software will be developed to retrieve, validate, correlate, format, and store the required data. A central data analysis network will then be established with remote access, as needed, to take advantage of data sources and pre-existing centers of expertise.

Knowledge-capture analyses will be conducted to develop assessment models that reflect actual ATM constraints, ATM procedures, ATM decisionmaking, delay causality, and costs to both operators and customers. These efforts will be carried out by a multi-disciplinary team of researchers and operational personnel at key facilities.

System models will be developed to analyze and interpret data, and special assessment reports will be produced that address specific questions posed by FAA senior management, R,E&D project leaders, and customers. Quick-reaction reports will also be produced to track impacts of new systems during their introduction phase. A related benefit of this project will be the generation of data bases for use in project-specific R,E&D simulation activities.

**Related Projects:** 021-110 Advanced Traffic Management System (ATMS), 021-140 Oceanic Air Traffic Automation, 021-200 Surface Movement Advisor, 023-120 Separation Standards, 025-130 National Simulation Capability (NSC), and 025-140 System Performance and Investment Analysis. Capital Investment Plan projects: A-01 En Route Automation Program, A-02 Tower Automation Program, A-04 Standard Terminal Automation Replacement System (STARS), A-05 Traffic Management System (TMS), A-06 En Route Software Development, A-10 Oceanic Automation Program, and A-11 Terminal Air Traffic Control Automation (TATCA).

### Products:

- Data assimilation/retrieval network
- Quick response assessment studies
- Flight delay causality and system constraint assessment

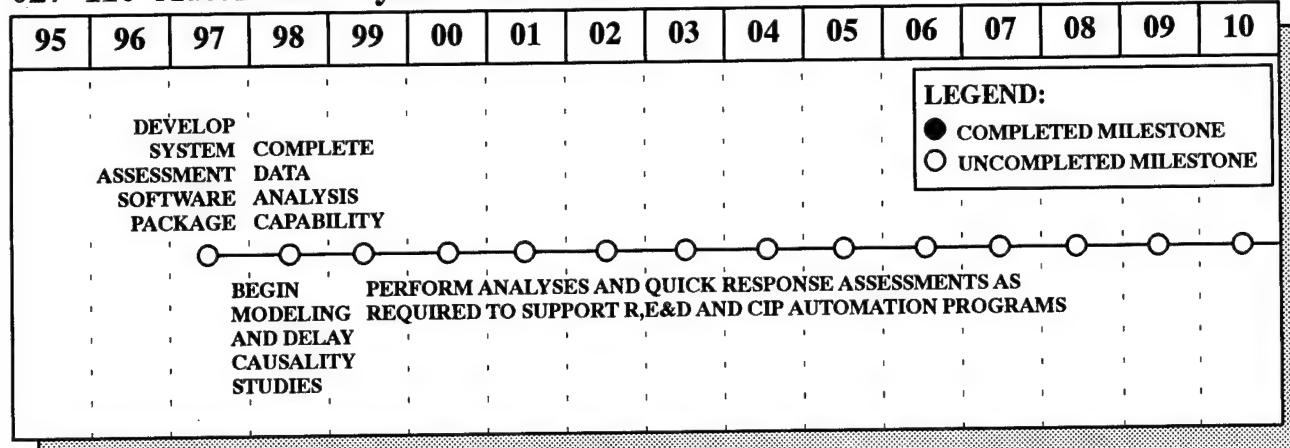
- ATM assessment models
- Cost/benefit metrics to support ongoing NAS effectiveness measurements

**1996 Projected Accomplishments:**

None. New start in 1996.

**Planned Activities:** In 1997, an initial automation system assessment software package will be developed, and work will begin on the data analysis network. By 1998, the data analysis capability will be operational, and delay causality studies and modeling will begin. Beginning in 1999, numerous analyses and quick-response assessments will be conducted to support R,E&D and CIP automation programs.

**027-110 Automation System Assessment**



### **3.0 COMMUNICATIONS, NAVIGATION, AND SURVEILLANCE**

The air traffic management (ATM) system's ability to support safe and efficient future flight operations is critically dependent on a high-performance, reliable, cost-effective communications, navigation, and surveillance (CNS) infrastructure. Because these systems require avionics development and certification, the FAA takes an active role in assessing and defining system requirements, strengths, and characteristics for appropriate integration into the ATM system.

The sensor and computer technology to provide the desired CNS infrastructure is an extension of successful commercial and military developments during the 1980's. One key technology is a high capacity air mobile communication system that permits automated communications between the cockpit and the ground computer automation products being developed in Chapter 2. The International Civil Aviation Organization (ICAO) has recognized the need to develop international standards for this capability and has directed the Secondary Surveillance Radar Improvements and Collision Avoidance Systems Panel to include this standardization activity in its work program.

Another key technology is applying satellites to ATM. The satellite's role in future CNS systems has been highlighted by the Future Air Navigation System committee established by ICAO in 1983. The FAA has adopted the committee's recommendation as a basis for its CNS research program. This technology offers a number of opportunities to improve CNS coverage, accuracy, and reliability. Aircraft users are antic-

ipating sufficient benefits and are aggressively planning to incorporate this technology in future airframe deliveries by developing appropriate interface standards. It is essential that the FAA proactively pursue this technology so that validated standards and certification criteria are available in a responsible timeframe. The Research, Engineering and Development (R,E&D) challenge is to provide this CNS infrastructure by the mid-1990's for inclusion in the next generation aircraft.

Enhancements in CNS achieved through these R,E&D projects provide the basis for dramatic improvements in system performance including improved safety, reduced delay, increased capacity, and greater efficiency. These three functional areas represent key ATM infrastructure elements. For this reason, many of the quantitative benefits from this area will be realized by implementing projects in the capacity and ATM technology thrust area. For example, the Aeronautical Data Link project, the Satellite Communications project, and the Satellite Navigation project provide the technology necessary to achieve the benefits associated with reducing oceanic separation standards in the Oceanic Air Traffic Control (ATC) Automation program.

Several projects in this thrust area are focused on replacing, at the appropriate time, existing systems with systems that have enhanced capabilities. The future benefits assessment for these projects will only focus on the enhancements' value.

The Department of Defense's (DOD) global positioning system (GPS) deployment, justified by national security requirements, has many civilian applications. The DOD has stated that GPS will be available, at no direct cost, for civilian applications for the next 10 years. Some projects in this thrust area are developing applications based on GPS as the future primary air navigation system. The benefit from these projects will be

the ability to forgo using the present very high frequency omnidirectional range (VOR)/distance measuring equipment (DME) network rather than replace the present electronic equipment. Furthermore, the ability to use differential GPS to provide near-Category (CAT)-I landing capabilities could make this service available at virtually all airports.

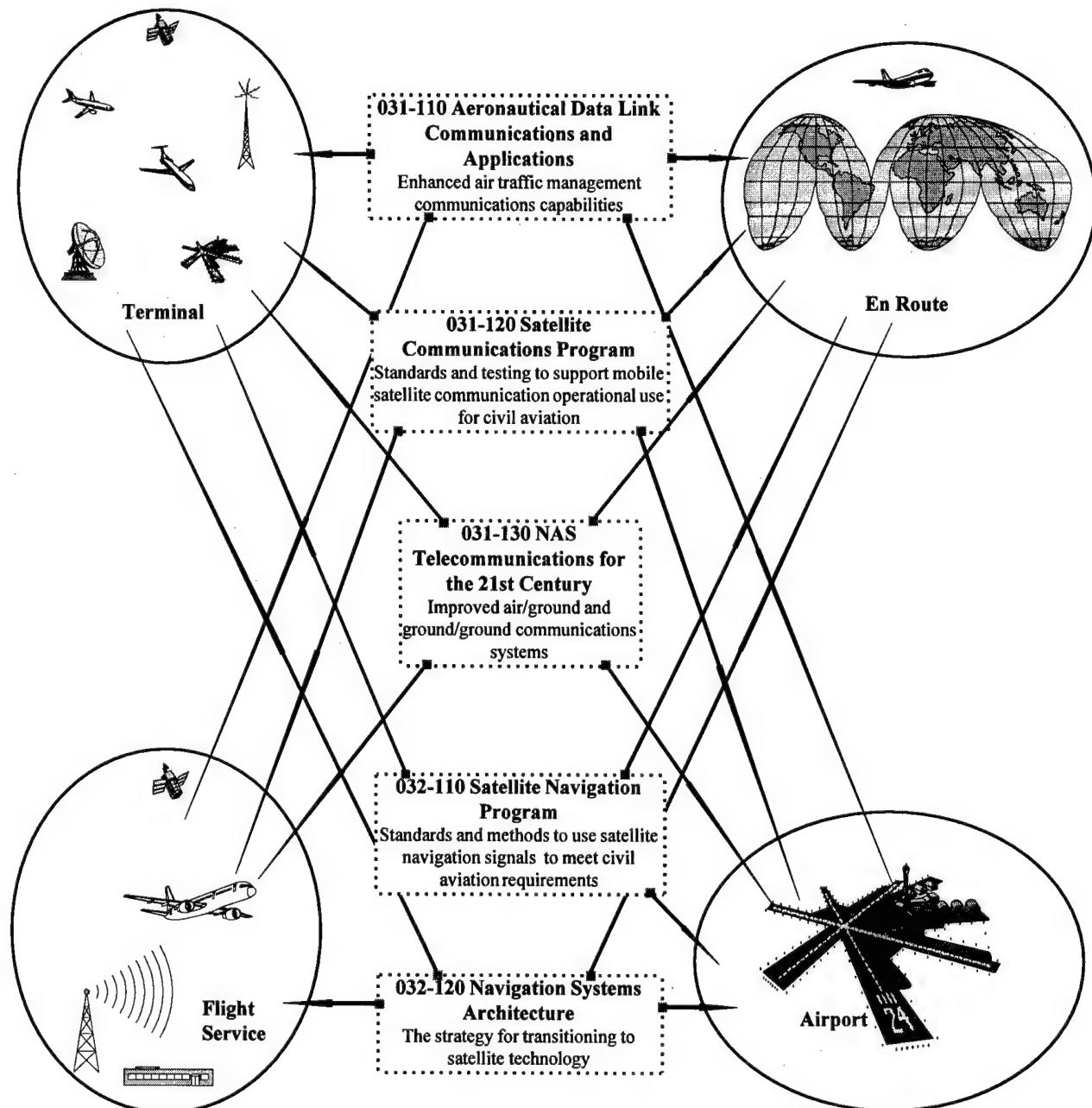
## **SUMMARY**

It is imperative that the FAA develop an aggressive and coordinated research program to exploit technological capabilities integrated into a safe and efficient ATM system that will satisfy future

needs. The emerging CNS systems must be integrated with the automation and weather programs to achieve the safe and efficient ATM system that is required.

# Communications, Navigation, and Surveillance Projects

## Contributions to FAA Services



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### 3.1 Communications, Navigation, and Surveillance Project Descriptions

#### 031-110 Aeronautical Data Link Communications and Applications

**P**urpose: Efficient airspace use is constrained by communications limitations in the existing air traffic control system. As the key enabling technology for free flight, aeronautical data link, when combined with advanced ground and air automation systems, will permit evolution toward an advanced air traffic management system. The enhanced ATM communications capabilities provided by data link will facilitate improved airspace utilization, delay reduction, and operating expense reduction. This project has two major elements: Communications and Applications.

##### Approach:

###### Communications

This project will develop and validate domestic and international data communications standards associated with the Aeronautical Telecommunications Network (ATN) as well as special purpose air/ground data link capabilities such as the global positioning system squitter. The ATN will be used for both air/ground and ground/ground data communications, for the National Airspace System (NAS), and international aeronautical communications. This project will also provide the technical communications framework for all NAS systems that plan to implement data link services/applications.

Communications protocols for aviation use will be developed, validated, and standardized both nationally and internationally. ICAO is developing standards to permit the incremental development, validation, and implementation of the ATN and associated user applications. The initial standards will be for a communications, navigation, and surveillance/air traffic management (CNS/ATM)-1 package. The standards associated with the CNS/ATM-1 package are currently being validated through international cooperative

agreements and with industry participation. Domestic standards are being developed with RTCA and will be consistent with the ICAO standards for the CNS/ATM-1 package. ICAO will define subsequent packages at approximately two- to three-year intervals.

The aeronautical data link program is supporting government/industry development of ATN systems and certification tools through a cooperative agreement with ATN Systems, Inc.

A critical effort for this project is investigating the extended use of the GPS squitter, a periodic data link broadcast from a mode select (Mode S) secondary radar transponder, for delivering GPS-based aircraft position reports. This automatic dependent surveillance broadcast (ADS-B) concept, when applied, will provide an enabling technology that supports surveillance of aircraft while airborne and on the airport surface. This technology is being used as the basis for the development of the traffic alert and collision avoidance system IV airborne collision avoidance system. Additionally, this technology may serve as a basis for future cockpit display of traffic information, terminal, en route, parallel runway monitoring, and airport surface surveillance systems.

###### Applications

Essential to achieving benefits from ground and airborne automation systems, data link applications must be developed as the key enabling technology to permit efficient flight crew to controller communications. This project will develop the operational concepts, software specifications, and computer/human interfaces to integrate data link ground and airborne automation systems into the NAS. The initial standards for applications will be incorporated in the ICAO

standards for the CNS/ATM-1 package. ICAO will define subsequent packages at approximately two- to three-year intervals. Domestic standards are being developed with RTCA and will be consistent with the ICAO standards for the CNS/ATM-1 package.

Data link services in oceanic, en route, terminal, and tower environments are defined in coordination with the air traffic and aviation user communities. These services are being developed and evaluated by a team that includes air traffic controllers, pilots, and other system users as appropriate. Demonstrations will then be conducted with both ground and airborne system users to validate the overall operational system effectiveness.

Operational benefit assessments for initial and advanced data link applications will use high-fidelity ground and cockpit simulation facilities. The tower ATC services will be evaluated at selected airports in a fully operational environment with participating air carriers. Routine and hazardous weather applications will be demonstrated and evaluated in various simulation and airborne testbed facilities. Weather and aeronautical services such as traffic advisories, terminal weather information for pilots, and GPS squitter applications will be validated using this approach.

**Related Projects:** 021-140 Oceanic Air Traffic Automation, 022-110 Traffic Alert and Collision Avoidance System (TCAS), 022-150 Flight Operations and Air Traffic Management Integration, 023-120 Separation Standards, 031-120 Satellite Communications Program, 031-130 NAS Telecommunications for the 21st Century, and 084-110 Flight Deck/ATC System Integration. Capital Investment Plan projects: A-12 Airport Surface Target Identification System (ATIDS), C-20 Aeronautical Data-link, F-14 System Support Laboratory Sustained Support, F-15 General Support Laboratory Sustained

Support, M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance, S-02 Mode S, W-03 Terminal Doppler Weather Radar (TDWR) System, and W-07 Integrated Terminal Weather System (ITWS).

#### **Products:**

- United States and international ATN data communications, GPS squitter, and applications standards
- Operational concepts and specifications for production, automation, and communication systems that utilize/support data link
- Prototype systems and operational data link service evaluations
- Testbeds for developing, evaluating, and demonstrating ATN and its subnetworks, ATC applications, and weather and aeronautical services
- Test tools to support avionics certification

#### **1996 Projected Accomplishments:**

##### Communications

- Validate ICAO CNS/ATM-1 package standards and recommended practices (SARP's) through simulations, testbed evaluations, and limited flight tests.
- Participate in North Atlantic unified trials in cooperation with air carriers and other civil aviation authorities leading to operational evaluations of CNS/ATM-1 package.
- Develop preliminary ICAO CNS/ATM-2 package definition.
- Complete and validate generic specification for GPS squitter ground station.

- Complete and validate GPS squitter ICAO standard.
- Develop RTCA standards for ADS-B.

### Applications

- Develop functional specification for terminal ATC data link applications.
- Publish operational concepts and minimum operational performance standards (MOPS) for advanced flight information services.
- Conduct operational demonstration for terminal weather information for pilots.
- Conduct operational demonstration of data link integration with center terminal radar approach control (TRACON) automation system (CTAS) and advanced automated en route air traffic control (AERA).
- Demonstrate prototype general aviation and transport category data link avionics.

### **Planned Activities:**

#### Communications

In 1997, the ICAO SARP's for the CNS/ATM-1 package will be accepted by the ICAO Air Navigation Commission and distributed for review by ICAO member states. R,E&D activities will continue through 1999 to support developing and validating standards associated with the ICAO CNS/ATM-2 package. Also in 1997, ATN research, jointly sponsored by the FAA and the industry ATN consortium, will validate the system operations, and begin developing prototype avionics and certification test tools. In 1998, development will be completed on prototype avionics and certification test tools. This effort will lead to a cooperative operational evaluation, including flight tests, that will begin in 1998. Also in 1998, very high frequency (VHF) data link will be validated to support standards

approval in 1999. Between 2000–2005, research will be conducted to develop and apply standards for worldwide ATN operations as reflected in future ICAO CNS/ATM packages. Concept validation will take place by 2002 with validated requirements by 2005. Also, by 2005, specifications will be developed for end-state NAS ATN systems. Final worldwide ATN requirements will be developed by 2008 for future ATN implementation.

In 1997, development efforts will continue on air/ground and air/air GPS squitter surveillance applications. Specifications will be developed to use the GPS squitter for surveillance in low to moderate density ATC terminals. Also in 1997, specifications will be developed to use the GPS squitter for surveillance in en route airspace. Operational evaluations will be conducted in 1997 in the Gulf of Mexico for low altitude ATC surveillance. From 1997–2000, research will be conducted to define cost effective strategies for applying GPS squitter technology in high density terminals. From 2000–2004, prototype systems will be developed and used to validate the GPS squitter application in these terminals followed by a specification in 2005.

#### Applications

In 1997, research will continue on ATC data link services. Also in 1997, ATN-compliant tower automation will be developed enabling improvements to the direct predeparture clearance distribution. In 1998, data link will be fielded at key TRACON and en route sites. This project will provide transition support for these services through 2000. In 1997, operational procedures development and government/industry data link benefits studies will be completed for integrated data link, CTAS, and AERA services. Through 1997, specifications and prototypes will be developed for integrated data link services, with testbed evaluation completed in 1998. Integrated terminal service development will be completed in 1999, followed by integrated en route services in 2000.

In 1998, research will begin on developing advanced terminal and en route data link services. User needs and procedural benefits analyses will take place through 1999, followed by specification development in 2000 and testbed evaluation of prototypes in 2001. Advanced terminal service development will be completed in 2003, followed by advanced en route services in 2004.

In 1997, research will begin on developing surface data link services. Initial prototyping will be completed by 1998, with deployment in 2002.

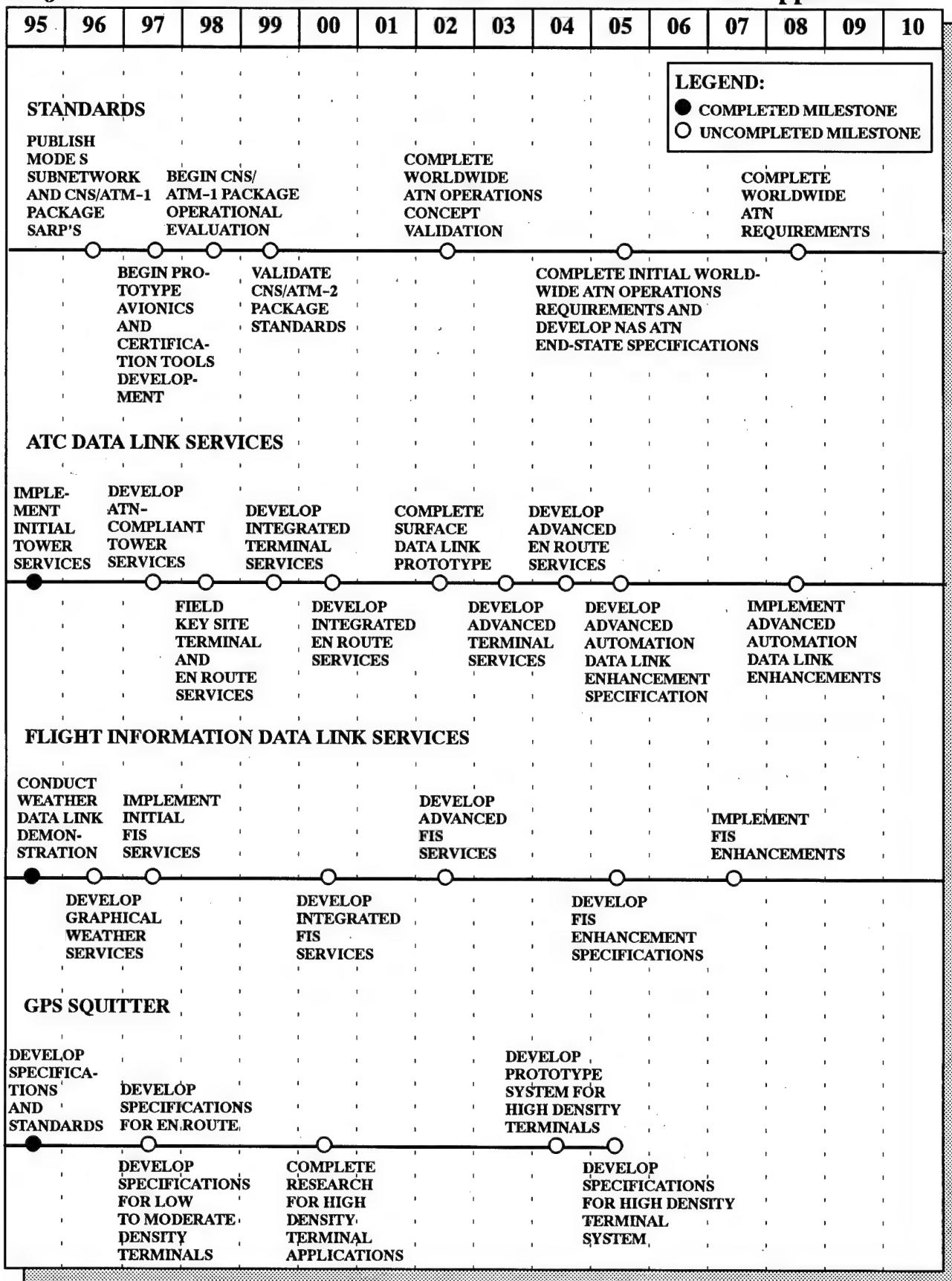
In 2001, research will begin on developing advanced automation data link enhancements. Commercial and general aviation experience with data link will be analyzed to produce next generation data link specifications. Using specifications developed by 2005, prototypes will be developed and evaluated on testbeds by 2006. These advanced automation data link enhancements will be implemented in 2008 through facilities and equipment (F&E) acquisition.

Initial flight information services (FIS) will be implemented in 1997. From 1997–1998, functional specifications will be developed and evaluated for the integrated FIS data link services. Prototypes will be designed and tested, and MOPS will be validated on FIS testbeds by 1999. Development work on integrated data link services will be completed in 2000.

Research and development for the advanced flight information data link services will begin in 1999 with analyses of FAA and industry experiences with previously implemented FIS data links. The analyses results will be used to generate specifications in 2000 and prototypes/evaluation testbeds in 2001. Advanced FIS development work will be completed in 2002.

In coordination with FAA automation programs, research for FIS data link enhancements will begin by 2003. Specifications will be developed by 2005, with prototyping and evaluation completed by 2006. Handoff of FIS automation enhancements to F&E is expected in 2007.

# Project 031-110: Aeronautical Data Link Communications and Applications



## 031-120 Satellite Communications Program

**P**urpose: The demand for oceanic airspace capacity is increasing due to an expected 50 percent traffic growth in the North Atlantic and 100 percent in the Pacific by 2000. Current communications are limited to high frequency (HF) voice radio only and are slow, unreliable, poor quality, and capacity constrained. Due to these technical constraints, real-time air traffic control cannot be accomplished in these regions, and transoceanic route capacity cannot be expanded to accommodate the rapidly growing demand. This project will develop the standards and perform required testing to support mobile satellite communication (SATCOM) operational use as an oceanic subnetwork to the aeronautical telecommunications network. Further research will be conducted to extend these capabilities to domestic airspace.

**Approach:** Three separate R,E&D projects are working together to bring satellite data and voice communications capabilities to oceanic areas. This project is integrated with the Aeronautical Data Link Communications and Applications and the Oceanic Air Traffic Automation projects to achieve increased safety, help reduce separation standards, and provide direct, reliable communications in the oceanic and remote areas. High frequency data link will be evaluated and standards developed to provide a complementary oceanic and remote communications network to SATCOM. This project is separated into four distinct initiatives:

### Developing SATCOM Data Capabilities for Oceanic and Remote Regions

The FAA will continue to support the international standards activities for implementing satellite data transmission in oceanic areas. Additionally, support will be provided to RTCA Special Committee 165 to develop MOPS and ensure that the MOPS are consistent with the SARP's.

Flight testing will be conducted to validate SARP's and MOPS with commercial airline participation over the North Atlantic in cooperation with European civil aviation authorities. A ground test facility will be used to conduct system end-to-end and radio frequency tests to validate standards not currently validated by manufacturers' data.

### Developing SATCOM Voice Capabilities for Oceanic and Remote Regions

This initiative is necessary to provide satellite voice capability between the cockpit and the air route traffic control center (ARTCC) in oceanic flight information regions. In conjunction with RTCA, a guidance document will be produced describing the full range of technical requirements to provide satellite voice capability. In coordination with the oceanic project office, an architecture will be developed that will enable controllers to send and receive direct satellite voice communications. This effort includes developing appropriate interfaces for FAA equipment. Flight trials will be conducted with major airlines to demonstrate/evaluate satellite voice capabilities.

### Implementing SATCOM Services in Oceanic and Remote Regions

This initiative addresses support for the Communications/Surveillance Operational Implementation Team (C/SOIT). This support includes technical expertise, analyses, and technical data. The team is responsible for developing operational regulations and procedures that implement satellite voice and data communications. The benefits derived from SATCOM require a combined effort among ATN, ADS, ARTCC automation, and SATCOM. The C/SOIT ensures the joint implementation of these efforts. Technical data will be collected from bilateral and multi-lateral engineering trials. This effort will integrate real-time end-to-end communications

and communication emulation capabilities into the Oceanic Development Facility.

#### Developing SATCOM Services for Selected Domestic Applications

The currently defined oceanic aeronautical mobile satellite services (AMSS) system may have applications in domestic areas. For example, offshore or mountainous regions where very high frequency does not penetrate could benefit from AMSS service. It is also possible that emerging SATCOM technology, including possible low earth orbiting or medium earth orbiting systems, can provide reliable and efficient data/voice capability that meets domestic requirements at a reasonable cost. This project will conduct feasibility studies and evaluations on lower cost, lightweight satellite communications avionics for general aviation and rotorcraft. Additionally, analysis is underway to determine architecture requirements for future SATCOM use.

**Related Projects:** 021-140 Oceanic Air Traffic Automation, 023-120 Separation Standards, 031-110 Aeronautical Data Link Communications and Applications, and 031-130 NAS Telecommunications for the 21st Century. Capital Investment Plan projects: A-10 Oceanic Automation Program (OAP), C-20 Aeronautical Data-link, and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- International AMSS SARP's with ICAO
- MOPS for AMSS avionics with RTCA
- Integrated ATN/AMSS model capable of testing end-to-end data communications

- Enhanced ATN AMSS model to include VHF digital link and Mode S subnetworks

#### **1996 Projected Accomplishments:**

- Conduct engineering trials with manufacturers' prototypes for satellite communications voice capabilities in oceanic and remote regions.
- Publish RTCA MOPS for SATCOM voice capability.
- Conduct engineering trials to collect high frequency data link propagation data.
- Complete architecture for SATCOM voice avionics.

#### **Planned Activities:**

#### Developing SATCOM Data Capabilities for Oceanic and Remote Regions

In 1998, ICAO AMSS MOPS and SARP's verification will be completed. Data collected during operational tests will be used in industry avionics bench testing for SARP's compliance certification and ICAO approval in 2000. The AMSS SARP's approval completes the R,E&D effort for this initiative.

#### Implementing SATCOM Services in Oceanic and Remote Regions

In 1997, data collection and analysis will continue from the North Atlantic engineering trials. Recommendations based on the data will be provided to the C/SOIT for regulatory and procedural implementation guidance. The C/SOIT plan specifies an incremental oceanic SATCOM implementation program that will be completed by 2000.

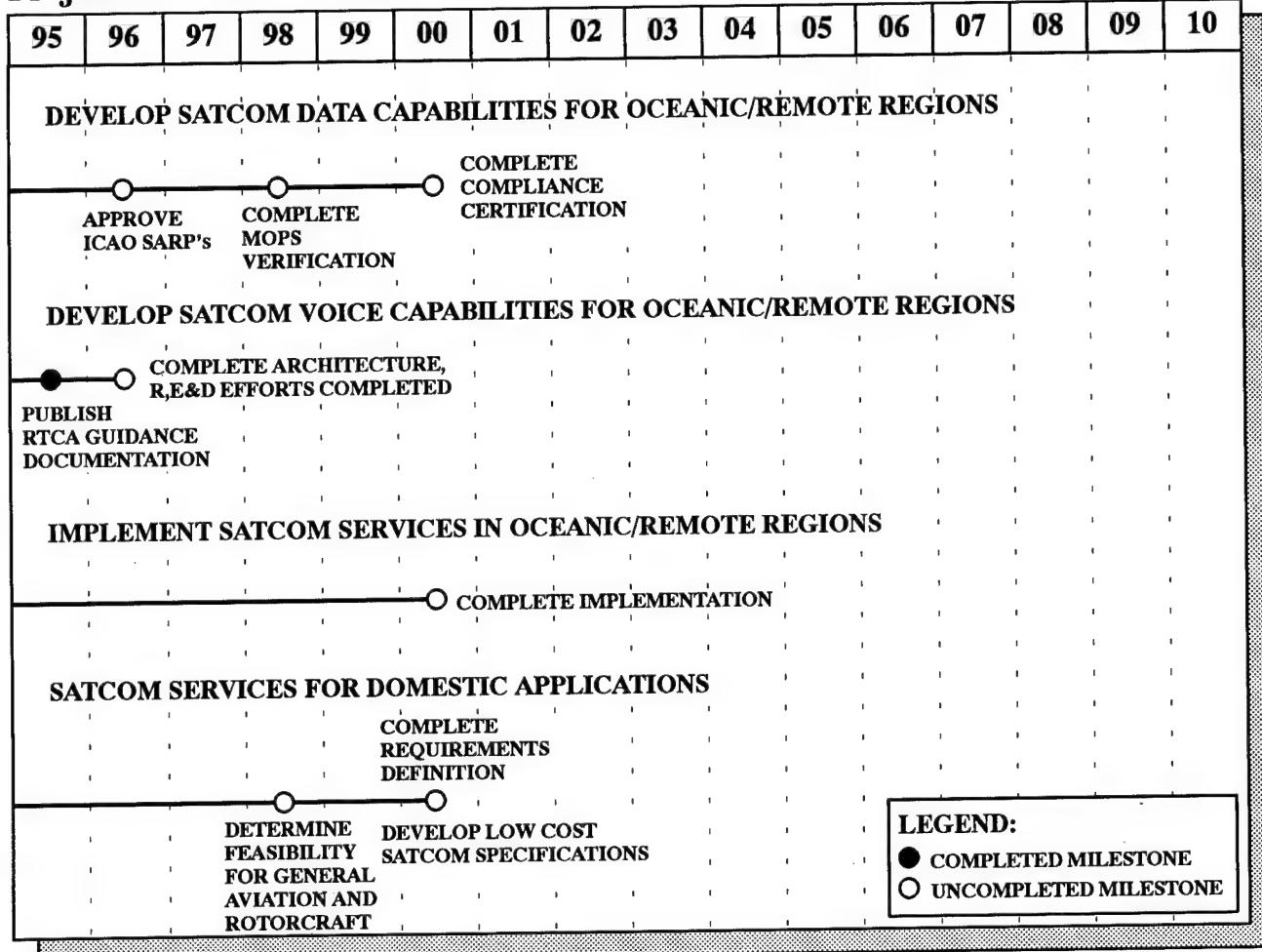
## Developing SATCOM Services for Selected Domestic Applications

In 1998, a feasibility determination will begin on lower cost, lightweight SATCOM avionics for general aviation and rotorcraft. From 1998-2000, a field evaluation using multiple, vendor-supplied prototypes will be conducted,

leading to updated RTCA standards for commercial off-the-shelf low-cost SATCOM avionics.

In 1998, further research based on the alternative SATCOM technology requirements definition will continue on long-term alternatives for providing SATCOM service in domestic areas. Anticipated completion for this effort is expected in 2000.

## **Project 031-120: Satellite Communications Program**



## 031-130 NAS Telecommunications for the 21st Century

**P**urpose: This project supports the next generation NAS communications system development by evaluating alternatives in new communication technology to satisfy future operational NAS requirements and goals. This effort is a multiyear project that is intended to speed the introduction of new technology into the NAS communications system. The current priority is to improve the air/ground and ground/ground communication systems.

A key shortfall in the current VHF air/ground system is the lack of capacity to accommodate increasing traffic load. Competition for additional frequency spectrum is intense and will constrain internationally allocated VHF frequencies. Expanding VHF system capacity will require new VHF radios for both the FAA and user communities.

Currently, a selected group of civil aviation telecommunication standards are not compatible with international standards of organization (ISO). As a result, the FAA is developing a set of standards to satisfy NAS aeronautical telecommunication requirements. This project will ensure conformance of those FAA-developed standards with the open systems interface model. These standards will enable the FAA to use commercial off-the-shelf products.

**Approach:** This project is separated into two distinct initiatives: Digital VHF Voice and Data System and Open Systems Interface Standards.

### Digital VHF Voice and Data System

This project will demonstrate how new technology will benefit the next generation NAS communications system. Overall objectives include: focusing R,E&D funding on leveraging new technology; reducing communication system cost; and adhering to a disciplined system engineering approach.

New technologies will be explored to quantify their performance in meeting NAS capacity and reliability requirements. Key factors to consider are: using commercial equipment whenever possible; streamlining operations; developing a transition plan; and integrating with other NAS elements. A cost/benefit study will be completed for each potential technology, and a trade-off analysis will be performed among alternatives.

Air/ground VHF digital voice and data communication system requirements, operational concepts, system design, and appropriate standards will be developed. Technology transfer efforts will be initiated to facilitate industry participation in system development. Furthermore, high risk system elements will be thoroughly prototyped and tested. Challenges this project will face during system development include: accommodating evolving national and international communication standards and applying global addressing, routing, and network management technologies.

### Open Systems Interface Standards

This project will utilize National Institutes of Standards and Technology expertise and capabilities in the open system interface standards and protocols to assure FAA compliance with international standards as well as to keep abreast of the latest developments in open system services.

**Related Projects:** 021-140 Oceanic Air Traffic Automation, 031-110 Aeronautical Data Link Communications and Applications, and 031-120 Satellite Communications Program. Capital Investment Plan projects: A-10 Oceanic Automation Program (OAP), C-20 Aeronautical Data-link, C-21 Next Generation Air/Ground Communications System, M-07 National Infrastructure Management System (NIMS), M-15 National Airspace System Spectrum Engineering

Management, and W-07 Integrated Terminal Weather System (ITWS).

#### Products:

- Internationally compatible requirements and standards for a new VHF air/ground communication system
- New VHF communication system design specifications
- New VHF communication system prototype, including flight demonstrations
- Performance specifications for F&E transition to solicit request for proposal for system procurement
- National Institutes of Standards and Technology report certifying conformance or identifying areas of non-conformance with ISO standards

#### 1996 Projected Accomplishments:

- Complete VHF voice coding specification validation.
- Issue digital VHF voice and data SARP's.

#### Planned Activities:

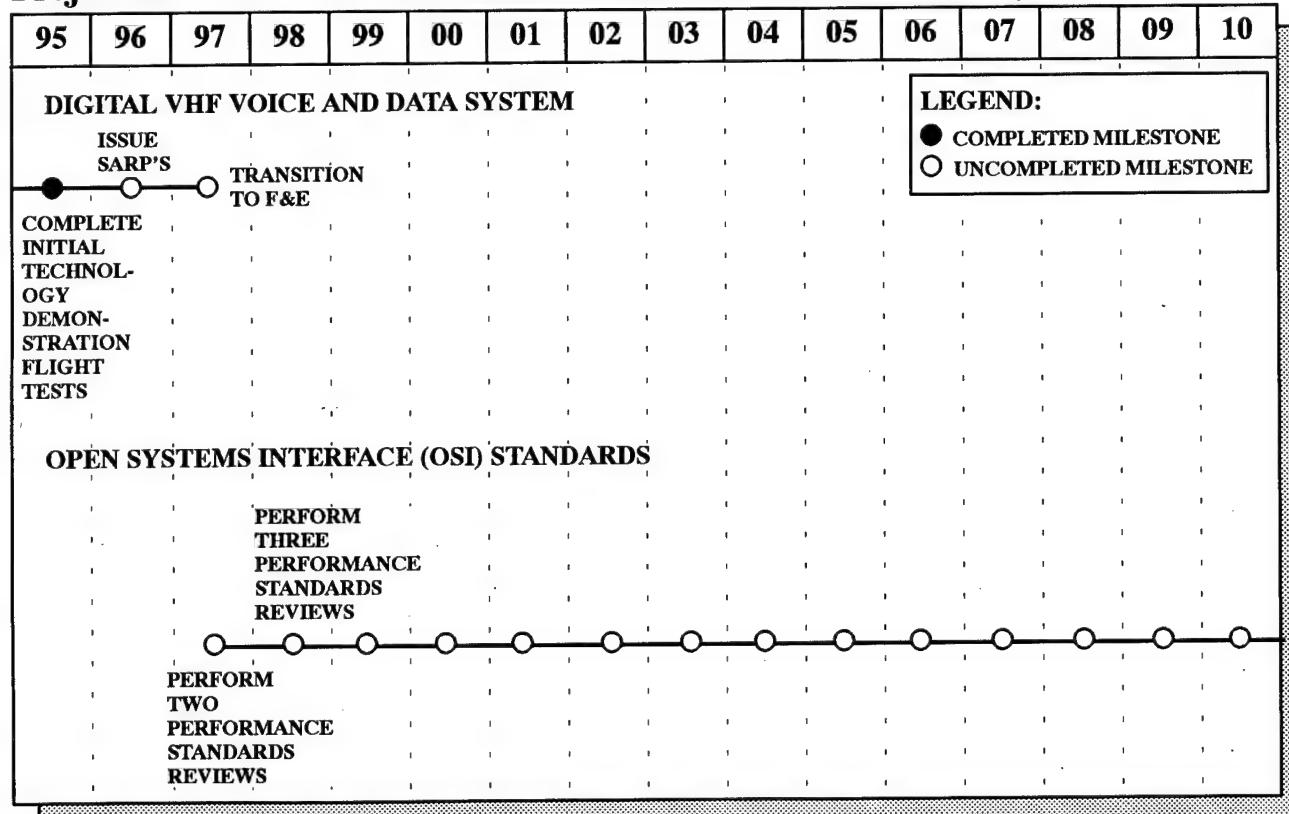
##### Digital VHF Voice and Data System

Standards and recommended practices will be validated in 1997 for production equipment certification. Also in 1997, transition to F&E is scheduled to occur.

##### Open Systems Interface (OSI) Standards

In 1997, at least two FAA-developed standards for OSI conformance will be reviewed. Three conformance standards reviews will be conducted each year throughout the life of the project.

#### Project 031-130: NAS Telecommunications for the 21st Century



## 032-110 Satellite Navigation Program

**P**urpose: This project will develop augmentations to navigation satellites (e.g., the global positioning system) to support techniques, procedures, and standards to meet all civil aviation navigation needs using a single navigation receiver. Civil aviation navigation needs include oceanic, en route, and terminal navigation as well as non-precision approach, precision approach, auto-landing, and airport surface navigation. Satellite navigation presents opportunities for standardized worldwide civil aviation operations using a common navigation receiver and for significant improvements in safety, capacity, service flexibility, and operating costs. Adopting satellite navigation systems could lead to phasing out existing National Airspace System ground equipment while maintaining or improving existing service levels. In addition, satellite-based navigation systems provide the potential for new navigation and landing services not currently supported by existing systems.

**Approach:** This project will focus on developing standards, procedures, and methods to use the global positioning system to meet civil aviation requirements. Project activities include the development and acquisition of prototype GPS augmentation techniques such as the wide area and local area systems, development of a national satellite testbed, and the establishment of a national satellite system control capability. Project activities will investigate, research, develop, and acquire GPS augmentations for required navigation performance (RNP) for en route, airport surface, terminal, departure, non-precision, and precision approaches. All satellite navigation signals, ionospheric interferences, timing procedures, satellite ephemeris anomalies, and any other factors that impact on user accuracy, integrity, availability, and continuity of service will be addressed and corrective actions determined. The research and development will be evaluated through practical concept evaluation, studies, analyses, and flight trials/demonstrations utilizing the national satellite testbed.

The basis for determining future improvements will come from the evaluation of data collected by the National Satellite Operations Center which will monitor satellite activity, wide area augmentation system (WAAS)/local area augmentation system (LAAS) status, and user message information. The national satellite system will collate, coordinate, and direct all research and development activities which will determine WAAS option requirements definition, LAAS system requirements, and potential future system upgrades. The overall program will be directed by the Satellite Navigation Program office with support from the FAA Technical Center.

The Satellite Navigation Program is structured to support an integrated program team approach through four interrelated and complementary thrusts. These thrusts will focus on civil aviation service, operational implementation of the service, international activities to gain support and development of a seamless global navigation satellite system, and national airspace system interface applications.

**Related Projects:** 021-140 Oceanic Air Traffic Automation. Capital Investment Plan projects: A-01 En Route Automation Program, A-02 Tower Automation Program, A-04 Standard Terminal Automated Radar System (STARS), A-05 Traffic Management System (TMS), A-10 Oceanic Automation Program (OAP), A-12 Airport Surface Target Identification System (ATIDS), and C-20 Aeronautical Data-Link.

### Products:

- Wide area augmentation system
- Local area augmentation system
- National satellite testbed
- National Satellite Operations Center

- Satellite-based approach procedures
- Satellite-based minimum operational performance standards
- Satellite-based technical standard orders (TSO)
- Special category I (CAT I) minimum aviation system performance standards

#### **1996 Projected Accomplishments:**

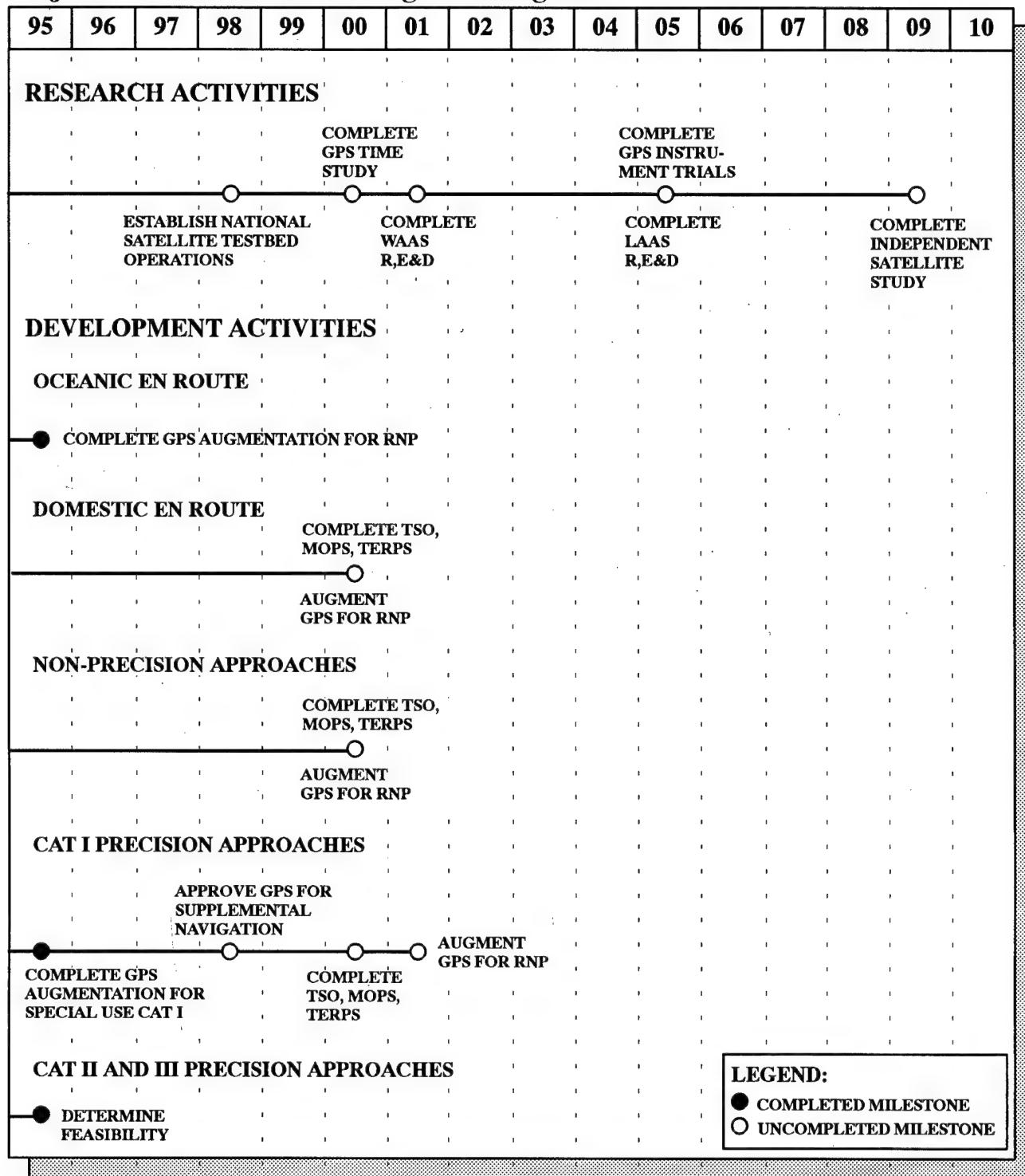
- Complete national satellite testbed hardware upgrades.
- Complete National Satellite Operations Center development.
- Define LAAS requirements.
- Complete environmental simulator.
- Complete national satellite testbed software algorithms.
- Complete technical standard order and minimum operational performance standards for WAAS non-precision approaches.

**Planned Activities:** In 1997, research will continue on developing standards and operational procedures to permit early satellite navigation system implementation for civil aviation. In 1998, research and development activities will include the establishment and utilization of a research test facility which will conduct aviation flight trials for GPS-instrumented aircraft operations in 2005. In 2000, improvements in GPS time transfer will be completed. Improved accuracy availability, integrity, and continuity of service will be provided by the completion of the WAAS in 2001 and the LAAS in 2005.

Beginning in 1997, research will investigate the control and operation of U.S. navigation satellites, with completion expected by 2009. Procedures and orders to support the above concepts will be developed, culminating in technical standard orders, minimum operational performance standards, and terminal instrument procedures (TERPS) in 2000 for en route through CAT I precision approaches.

GPS supplemental precision approaches to CAT I will be approved for public use in 1998, with RNP scheduled for 2001. In 2000, GPS augmented for RNP will be implemented in domestic en route airspace.

# Project 032-110: Satellite Navigation Program



## 032-120 Navigation Systems Architecture

**P**urpose: The FAA has the responsibility for developing and implementing radionavigation systems to meet the needs of all civil and military aviation, except those peculiar to air warfare. This project, in an integrated effort with other R,E&D projects, addresses transitioning to a satellite-based navigation system and developing the strategy for decommissioning older-technology ground-based systems. An important aspect is identifying and evaluating emerging technologies and new concepts for meeting future navigation service requirements.

Navigation Systems Architecture also supports the Federal Radionavigation Plan biennial revision and provides the FAA input to the joint Department of Transportation and Department of Defense Positioning and Navigation Working Group.

**Approach:** This project's emphasis is to support developing a NAS transition strategy that will provide guidance for a major shift to satellite technology. Research will focus on resolving three major issues: current navigation system supportability; transition to satellite-based navigation; and potential ground-based system phase-out.

Until a transition to satellite systems is completed, research will continue on phase-out strategies for current ground-based systems. Available technology will also be examined for the potential to enhance the GPS signal, if required.

Studies will be conducted to facilitate the transition to satellite navigation. Results will be validated in laboratory simulations to test their effectiveness. Research will focus on developing and validating advanced fault detection and exclusion algorithms to improve GPS receiver integrity monitoring in aircraft avionics and developing advanced GPS availability notification capabilities.

Studies and analyses will be performed to help complete development of the RNP concept for satellite-based approach and landing operations. The results from these efforts will help determine the specific RNP performance parameters to be applied. Recommendations will be provided to the ICAO All Weather Operations and Global Navigation Satellite System panels, the FAA Satellite Operational Implementation Team, and RTCA special committees for incorporation into appropriate standards.

Supplemental studies and analyses will be performed to support NAS planning and Federal Radionavigation Plan development. Based on the research results, recommendations will be made on the mixture of navigation systems required to support NAS operations. A national aviation standard will be developed and maintained for each system approved for use in the NAS.

**Related Projects:** 032-110 Satellite Navigation Program. Capital Investment Plan projects: M-03 System Engineering and Technical Support, N-03 Instrument Landing System (ILS), N-06 VORTAC, N-09 Sustain Distance Measuring Equipment (DME), N-10 Sustain Nondirectional Beacon (NDB), N-11 Loran-C Monitors and Transmitter Enhancements, and N-12 Augmentations for the Global Positioning System (GPS).

### Products:

- Fault detection and exclusion algorithms for improved GPS receiver integrity monitoring
- Advanced GPS availability notification capabilities
- National aviation standards for radionavigation systems

- Strategy for decommissioning existing land-based navigation systems
- Recommendation for the NAS radionavigation system mixture
- Biennial Federal Radionavigation Plan publication

#### 1996 Projected Accomplishments:

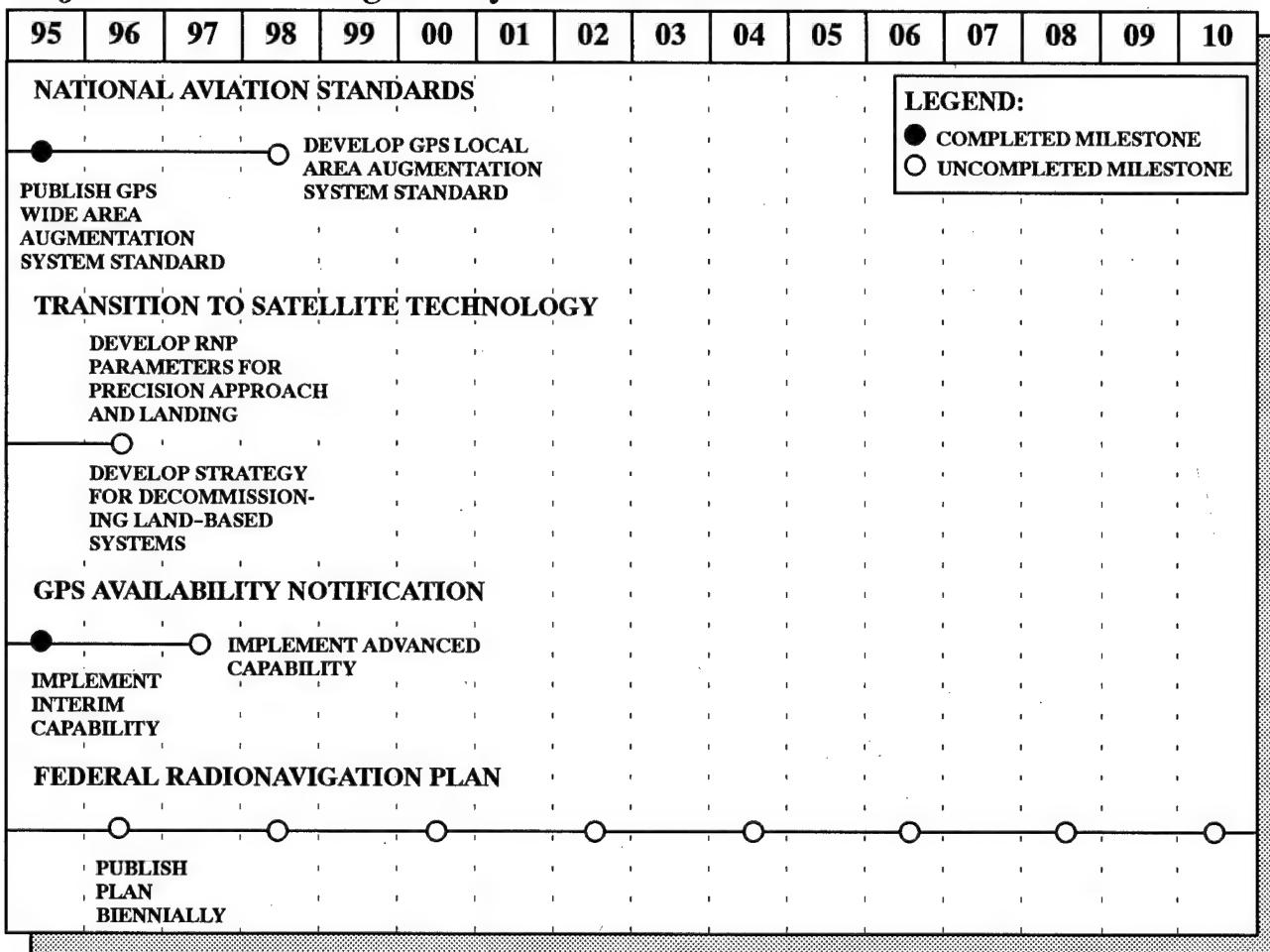
- Develop RNP parameters for precision approach and landing.
- Develop fault detection and exclusion algorithms for improved GPS receiver integrity monitoring.

- Publish the 1996 Federal Radionavigation Plan.
- Develop strategy for decommissioning existing land-based navigation systems.

**Planned Activities:** An advanced GPS availability notification capability will be implemented in 1997 to support GPS RNP requirements.

In 1998, a national aviation standard will be developed for the GPS local area augmentation system. Also in 1998, the next edition of the biennial Federal Radionavigation Plan will be published.

#### Project 032-120: Navigation Systems Architecture



## 4.0 WEATHER

Weather is, and will continue to be, a critical factor in all flight operations. It is the single largest contributor to delays and a major factor in aircraft accidents and incidents. Improved weather forecasts offer the potential for increasing system capacity more cost effectively than most other alternatives, such as new airports and runways. Better short-term forecasts and current information on hazardous weather conditions are critical to ensuring safe flight. Also, timely and accurate weather information is critical to planning fuel- and time-efficient flight plans. Weather service users encompass the entire aviation spectrum, from the student pilot to the operator of the most sophisticated, high-performance commercial aircraft during all flight phases.

The future air traffic management (ATM) system will require highly accurate real-time weather

warning products and short- and long-term weather forecasts, covering the time period from a few minutes, up to 3, 6, and even 12 hours into the future. Progress in weather research necessary to develop these products, and to implement a system infrastructure to deliver enhanced weather products to end-users, will be critical to addressing this need.

The aviation weather thrust area includes a combination of Research, Engineering and Development (R,E&D) weather projects and new Capital Investment Plan (CIP) weather initiatives that will build upon ongoing weather system development to realize the full user benefits. Both components are critical to the overall success of the weather system modernization effort.

### AVIATION WEATHER MISSION NEEDS

Good flight planning is necessary for all flight operations. A principal need is the capability to provide weather information to support hazardous weather avoidance. In a planning sense, the aviator needs to have good forecast information to avoid hazards in flight.

Efficiency is determined by minimizing time in flight or fuel used. Flight efficiency to a large degree implies the capability for economic or pilot-chosen routing. This capability implies a significant need for timely and accurate strategic weather information during flight planning so that a route can be selected to minimize the need for dynamic rerouting during flight.

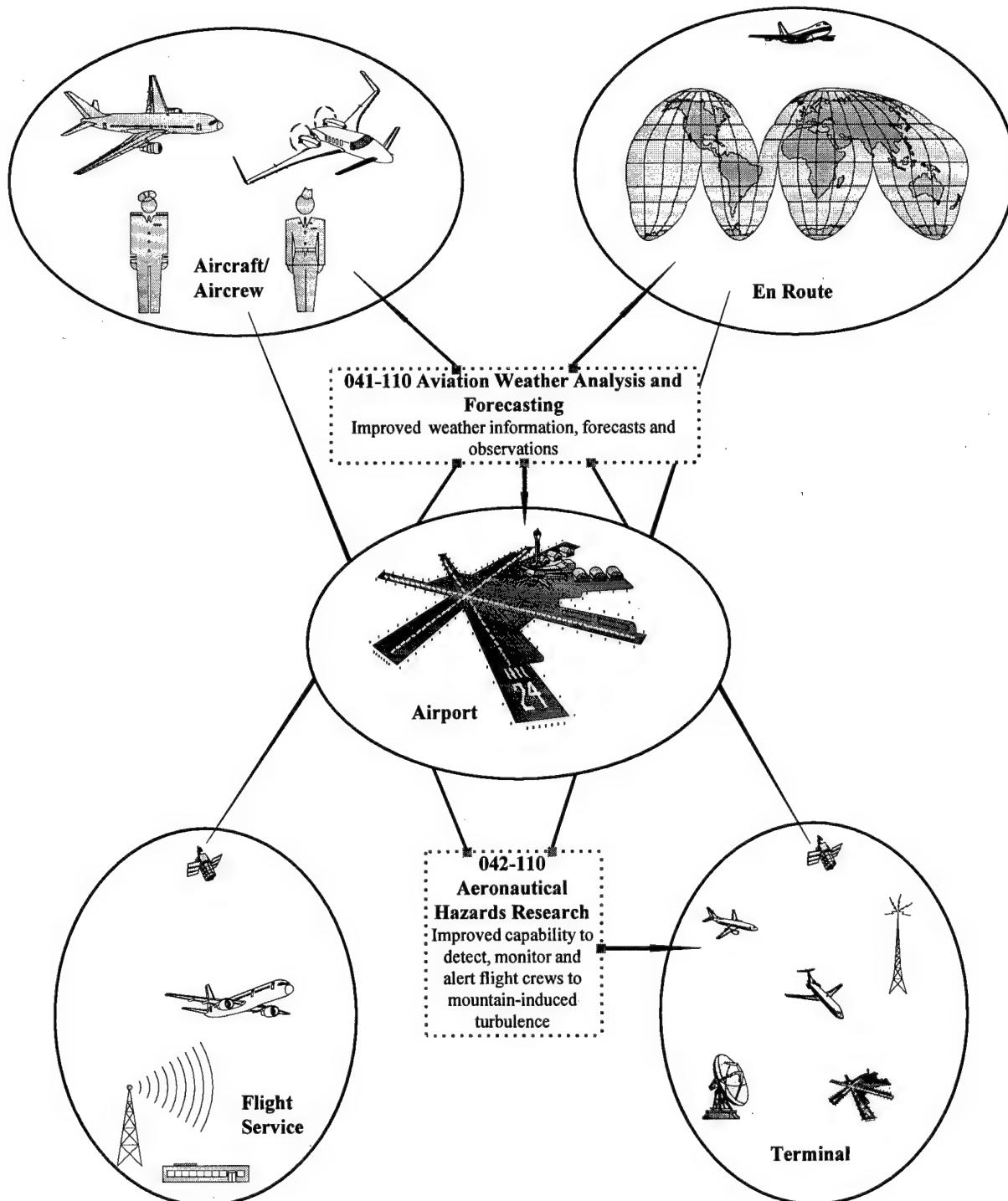
In the terminal area, predicting significant wind shifts is needed to optimize runway management. In addition, more accurate wind field analyses

will provide terminal air traffic automation systems with optimal descent profiles. Enhanced hazardous weather depiction will mitigate weather impacts on arrival and departure corridors. Improved windshear warnings, microburst detection, thunderstorm predictions, and other products will be particularly important in this regard.

Finally, with the increase in oceanic traffic, and in close connection with oceanic air traffic control, there is a need to establish oceanic weather warning and forecast centers that can provide timely weather information. Improved weather information will provide route flexibility commensurate with systems such as automatic dependent surveillance and will enhance transoceanic flight safety.

## Weather Projects

### Contributions to FAA Services



## 4.1 Weather Project Descriptions

### 041-110 Aviation Weather Analysis and Forecasting

**P**urpose: This project will enhance the basic understanding of weather as it affects aviation. Since weather impacts on the National Airspace System (NAS) are spatially small (mesoscale), this project will be integrated with other national research program activities that focus on the atmospheric mesoscale analysis and prediction problem. A further purpose is to concentrate research efforts on developing new algorithms, numerical weather analysis and prediction models, and methods to detect/predict the impact from weather hazards. This research will significantly improve weather product and forecast quality, thus enabling aviation weather users to make effective strategic and tactical decisions for aviation operations.

This project will also develop a specialized airborne humidity sensor to meet unique, critical aviation weather requirements for 3-dimensional moisture data. Ground-based sensors alone cannot provide the 3-dimensional information needed to create accurate icing and visibility forecast products. This airborne sensor will provide new moisture data for icing forecasts in the terminal and en route airspace.

**Approach:** This project includes four major components: (1) participating in interagency activities to better understand aviation weather phenomena; (2) developing models and algorithms for generating nowcast and short-term aviation-specific products; (3) developing and testing algorithms for the WSR-88D next generation weather radar (NEXRAD) product improvements; and (4) developing an airborne humidity sensor. Product areas include icing forecasts; en route and transition turbulence, ceiling, and visibility; thunderstorm and microburst prediction; and wind analysis and forecasting.

The objectives in the weather R,E&D program are incorporated in the stated goals of the U.S.

Weather Research Program (USWRP), which is a congressionally mandated interagency program under the lead of the National Oceanic and Atmospheric Administration. The FAA will participate in the USWRP to address regional and local scale weather phenomena that are unique to aviation. The USWRP's strategic priorities of most interest to the FAA are to "improve local and regional weather forecasts" and to "achieve efficiencies by coordinating efforts of federal agencies, state institutions, the academic research community, and the private sector." Involvement in the USWRP will benefit a significant portion of the R,E&D program.

The major objective for icing forecasting improvements is to develop an aircraft icing forecast capability. This capability will provide accurate delineation of actual and expected icing areas by location, altitude, duration, and potential severity. Another element in the icing program is to create a capability to forecast the onset, intensity, and cessation of structural icing on the ground to support anti-icing activities.

Detecting and avoiding clear air turbulence can improve NAS safety and capacity. This research effort will develop a model for short-term en route and transition turbulence forecasting using wind, temperature, and moisture data. A variety of models will be developed and applied to forecasting wind flow patterns, downbursts, wind direction changes, windshear, and gust fronts for the lower atmosphere.

This research and development project is being coordinated with and accomplished through interagency agreements with the National Science Foundation and the National Oceanic and Atmospheric Administration. The Aviation Weather Analysis and Forecasting project will provide current analyses, nowcasts, and short-range predictions of relevant atmospheric fields

and hazardous weather phenomena. Products derived from the above information will be tested and evaluated at the Aviation Weather Development Laboratory (AWDL) in Boulder, Colorado, and the Experimental Forecast Facility (EFF) at Kansas City, Missouri, to facilitate transition of appropriate products to operational aviation weather services and industry through cooperative research and development agreements.

**Related Projects:** 042-110 Aeronautical Hazards Research and 064-110 Flight Safety/Atmospheric Hazards. Capital Investment Plan projects: M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance, W-04 Weather and Radar Processor (WARP), and W-07 Integrated Terminal Weather System (ITWS).

#### **Products:**

- Precise and usable algorithms and/or numerical models related to icing, turbulence, convective initiation, visibility, ceiling, and snowstorm forecasting
- New mesoscale numerical data assimilation and prediction models adapted to aviation needs and new methods for nowcasting
- New prototype aviation weather products for the AWDL, EFF, and industry test and evaluation
- Automated techniques for detecting, quantifying, and forecasting meteorological events
- Prototype humidity sensor

#### **1996 Projected Accomplishments:**

- Demonstrate aviation gridded forecast system (AGFS) at the National Weather Service.

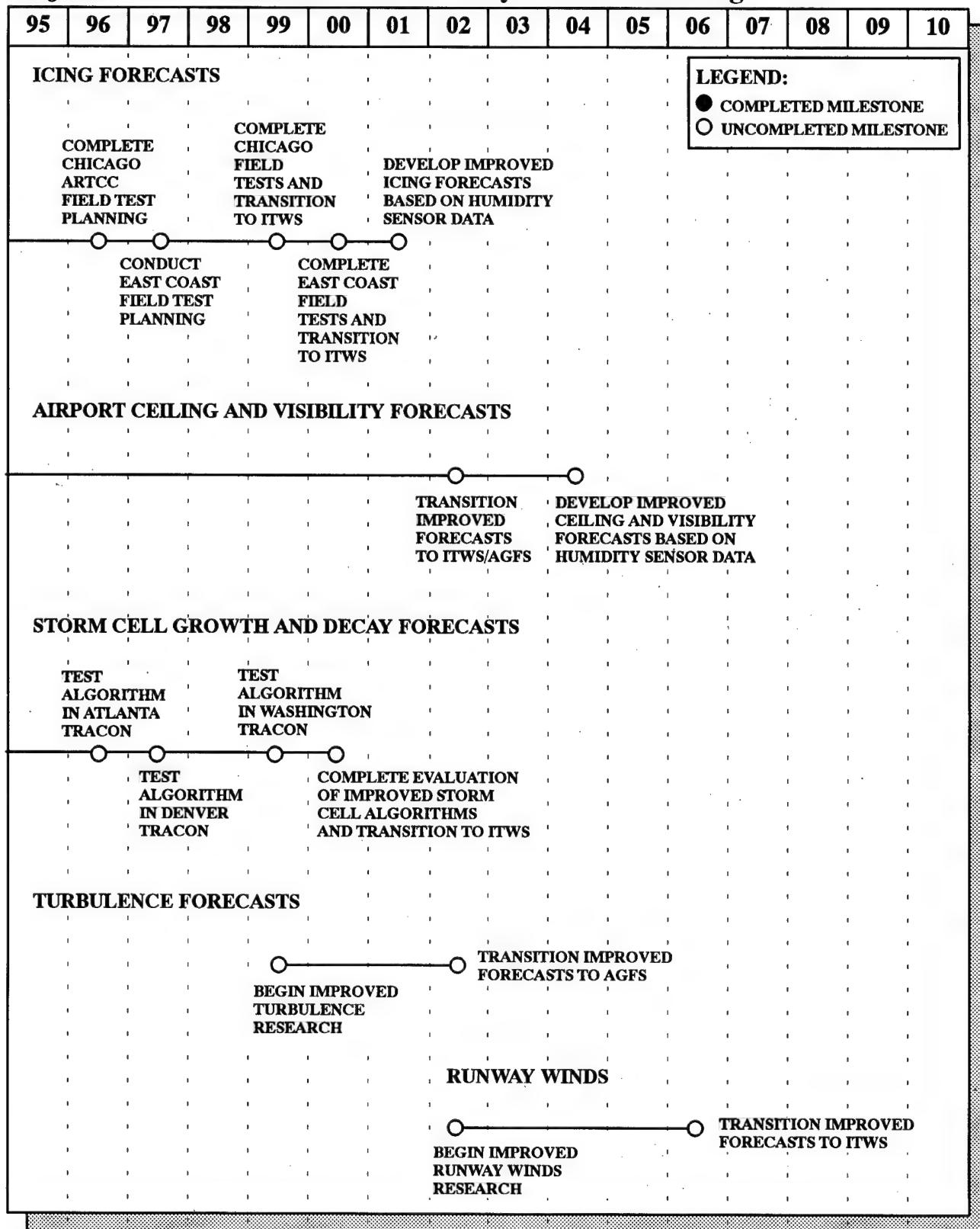
- Flight certify and demonstrate the airborne humidity sensor.
- Develop field program plans to test inflight icing forecasts and snowfall rate prediction for ground anti-icing in the Chicago air route traffic control center (ARTCC) area.

**Planned Activities:** From 1997-1999, thunderstorm autonowcast algorithms will be evaluated at the Denver and Washington Center Weather Service Units. During the winter of 1997-1998, winter icing forecast technique field tests will be conducted in Chicago; the results will transition to the ITWS in 1999. In parallel with the Chicago field test, planning for an east coast field test at either Boston or Washington will be completed in 1997. The east coast field test will run from 1998-1999, and the algorithms will transition to the ITWS in 2000. Improvements in icing forecasts will continue through 2001 by using the high resolution humidity data available from the airborne humidity sensor.

In 1999, research will continue on automating changes in ceiling and visibility forecasts at airports, with improved forecasts transitioning to the ITWS and the national aviation gridded forecast system in 2002. Further improvements will be developed between 2002 and 2004 using the high resolution humidity data from the airborne humidity sensor. Turbulence forecast improvements will be developed between 1999 and 2002. Improved runway wind forecasts will be developed between 2002 and 2006. Turbulence and runway winds forecasts will transition to AGFS and ITWS respectively.

This project is coordinated with the Aeronautical Hazards Research project to provide scientific meteorological expertise on mountain rotor.

# Project 041-110: Aviation Weather Analysis and Forecasting



## 042-110 Aeronautical Hazards Research

**P**urpose: This project is designed to improve safety by responding to specific National Transportation Safety Board recommendations on aeronautical hazards. Mountain wave aeronautical hazards, such as mountain rotors, are significant factors in weather related accidents/incidents. This project will collect data and analyze systems to validate technology for detecting hazards. This research will provide an improved operational capability to detect, monitor, and alert flightcrews to aeronautical hazards.

**Approach:** Following the Colorado Springs air carrier accident in 1991, the National Transportation Safety Board recommended that the FAA develop and implement a meteorological program to observe, document, and analyze aircraft hazards in mountainous areas with a focus on approach and departure paths. This project will study mountain wave phenomena to develop procedures and technology for detecting and avoiding these hazards. Initial research will be conducted to define the hazards and collect data on mountain rotors. A training manual will be developed to enhance aircrew awareness and provide procedures for hazards avoidance.

An important element in this project is leveraging research from the Wake-Vortex Separation Standards project to aid in the detection and avoidance of mountain wave hazards. Certain similarities between the mountain wave and wake-vortex hazards provide an opportunity to integrate research in a collaborative effort. However, sensor technology gained from the wake-vortex project will need to undergo development work to make it applicable for detecting mountain wave hazards.

**Related Projects:** 021-230 Wake-Vortex Separation Standards and 041-110 Aviation Weather Analysis and Forecasting. Capital Investment Plan projects: M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

### Products:

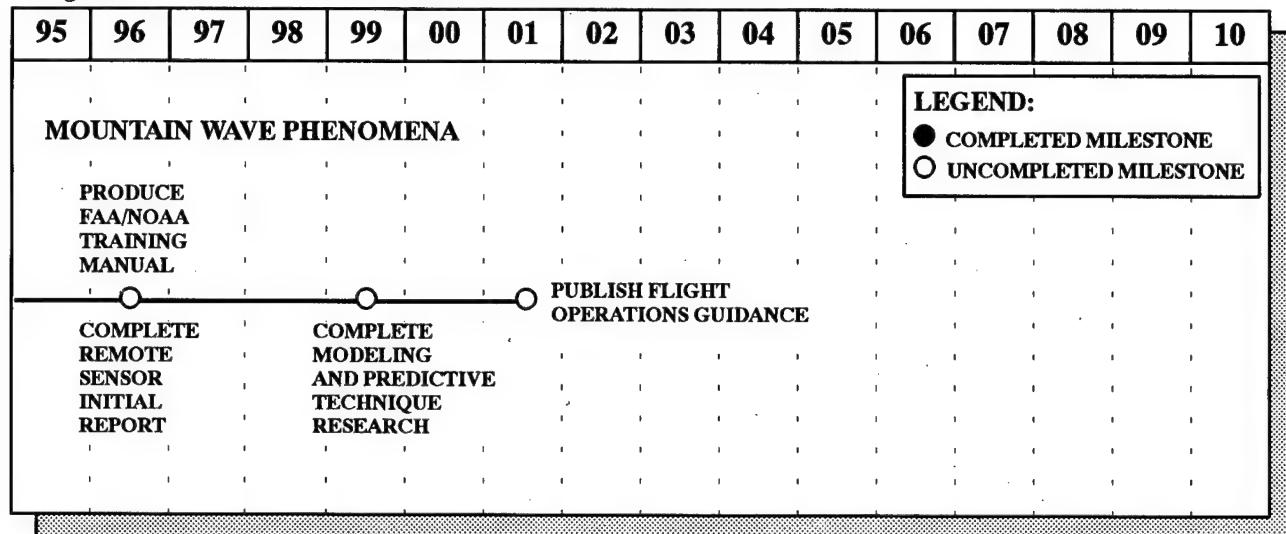
- Hazards definition
- Pilot training manual
- Improved modeling and predictive techniques
- Guidance for flight operations

### 1996 Projected Accomplishments:

- Complete initial report on evaluation of remote sensors for hazards detection.
- Produce joint FAA/National Oceanographic and Atmospheric Administration (NOAA) pilot training manual.

**Planned Activities:** In 1997, mountain wave phenomena research will continue, and a comprehensive program to create a series of operational products for pilots and the aviation community will begin. Also in 1997, improved modeling and predictive techniques research will begin with completion expected in 1999. Guidance for flight operations will be published in 2001.

## Project 042-110: Aeronautical Hazards Research



## 5.0 AIRPORT TECHNOLOGY

The FAA is responsible for encouraging and fostering safe and efficient national airport system development. The Airport Technology Research and Development Program assists in developing new and improved standards, criteria, and guidelines to plan, design, construct, operate, and maintain the Nation's airports, heliports, and vertiports.

There are over 18,000 aircraft landing areas in the United States. Aircraft are increasing not only in number, but more importantly, in weight, landing speed, and overall dimensions. Many airport facilities are reaching design life, and the capital costs of airport improvements over the next 5 years are estimated to exceed \$30 billion. Research will be an important factor in the efforts to control costs. Both passenger enplanements and aircraft operations are projected to experience strong growth for the foreseeable future, leading to airport activity levels two or more times greater than today. However, there are limited possibilities for expanding existing airports or building new airports. Consequently, maximum benefits must be derived by maintaining and improving existing facilities and by supporting research that can reduce congestion and delays at airports. Research can also provide innovative means for improving safety, increasing capacity, improving airport access and passenger services, assessing federal investment

effectiveness, and supporting U.S.-developed aviation products.

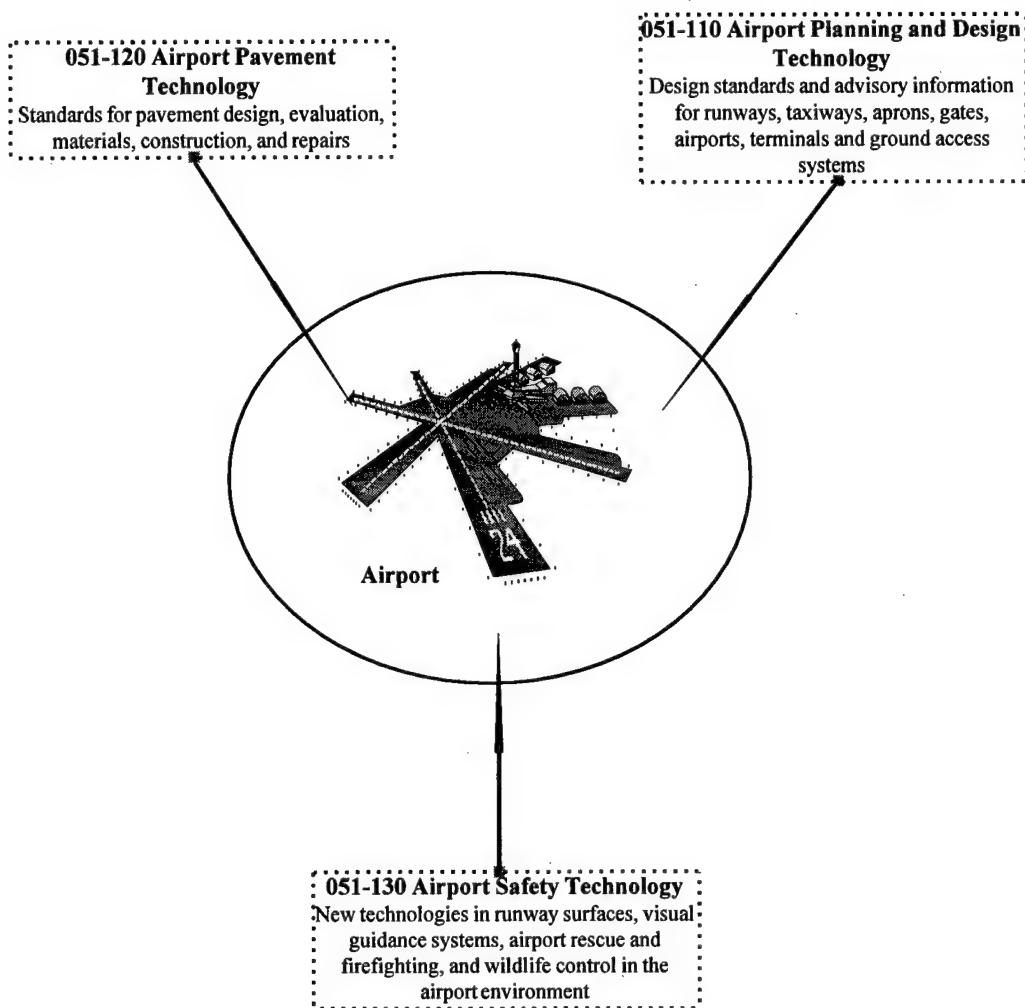
Airport technology research can lead to improved designs, techniques, equipment, and methods to assess system performance that will increase federal investment effectiveness of the \$1.5 billion Airport Improvement program as well as the even greater investments in infrastructure made by the owners and users of the airport. For example: pavement and other facility life-cycle costs can be reduced; capacity can be improved and delays reduced; and both airports and heliports can be better integrated into the National Transportation System.

Pavement research has the potential for very large benefits. Approximately \$2 billion is spent on constructing, rehabilitating, and maintaining airport pavements each year, whereas only \$3 million is spent on research. Increasing the average life of pavements by as little as 10 percent through research would result in a cost/benefit ratio of 50 to 1 or more. This objective is not unreasonable or unattainable.

The landside portion of airport design and operation is also addressed in this research area. Projects in this area will help ensure that the systems that bring passengers to the aircraft are also able to handle forecasted traffic levels.

## Airport Technology Projects

### Contributions to FAA Services



## 5.1 Airport Technology Project Descriptions

### 051-110 Airport Planning and Design Technology

**P**urpose: This project will help improve existing, or develop new, design standards pertaining to runways, taxiways, aprons, and gates. It will also develop standards and advisory information to be used in planning and designing airports, terminals, and ground access systems.

Advances in technology have supported major refinements in the air transportation system and made it possible to transport a large number of people, one-half billion passenger enplanements, each year. But ever-increasing travel demand and projected growth in the next 15 years will influence airport design, layout, and configuration, and require improved landside facilities. A major concern facing the U.S. air transportation industry is how to manage increases in air traffic with improved safety, reduced delays, and minimal operational constraints.

As advances in air traffic control and other airport improvements increase airside efficiency and capacity, passenger facility capacity and access to the airport will become a limiting factor. As passenger facility capacity and airport access become the new limiting factors, these choke points will generate greater community interest and involvement. Optimum airport use will require a smooth and uninterrupted flow of passengers, cargo, and airplanes among the various elements of the airport system.

**Approach:** A major goal of this program is to reduce runway occupancy time as much as practical. It will require optimizing the geometry of runway and taxiway exits to allow aircraft to negotiate turns safely at higher speed. Research will also be needed to support changes in airport ground access to respond to concerns about con-

gestion and air quality. In addition, it is necessary to identify the clearance and design requirements of future aircraft and review current airport designs relative to those requirements. Also, simplified methods must be developed for determining terminal, curbside, and airside capacities.

**Related Projects:** 021-220 Multiple Runway Procedures Development, 024-110 Aviation System Capacity Planning, 051-120 Airport Pavement Technology, 051-130 Airport Safety Technology, and 073-110 Airport Security Technology Integration. Capital Investment Plan projects: F-16 FAA Technical Center Building and Plant Support and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### Products:

- Technical data to support advisory material, regulations, and guidance used by the FAA and industry
- Computer programs and user guides for use by the FAA airport community and industry
- Design standards for terminals and multiple/parallel runway configurations
- Aircraft/terminal compatibility analyses

#### 1996 Projected Accomplishments:

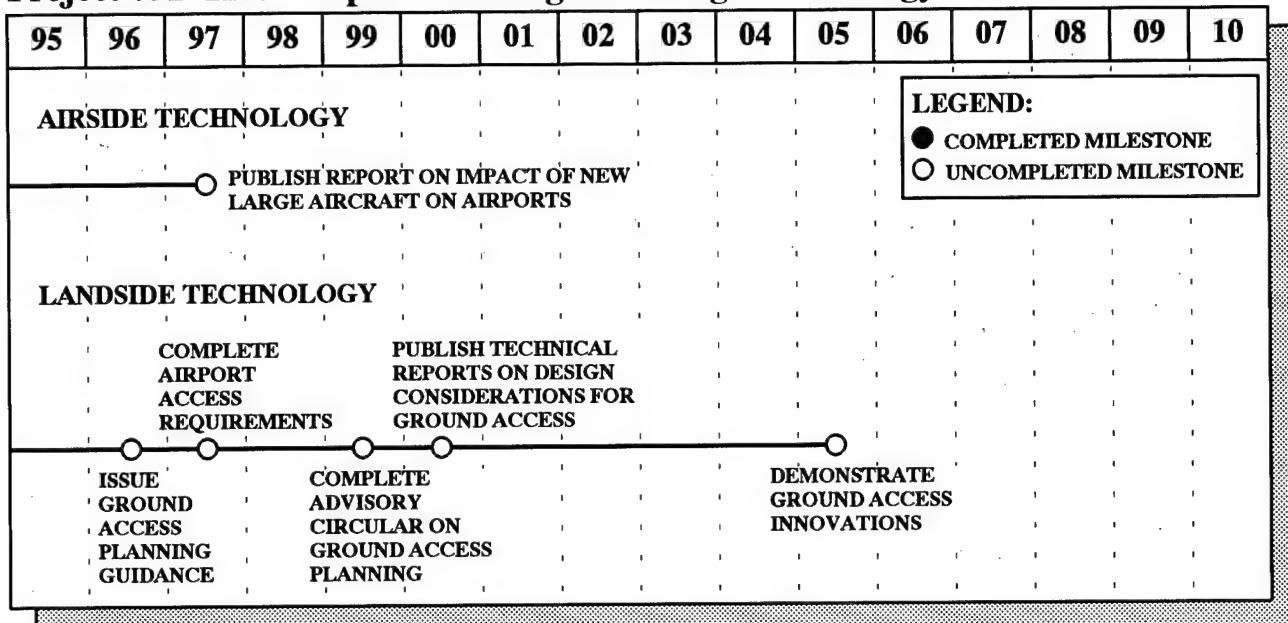
- Issue ground access planning guidance.
- Publish report on the effect of proposed very large civil transports on airports.

**Planned Activities:**Airside Technology

In 1997, a report will be prepared on the impact of new larger aircraft on airports, and a review of all guidance material contained in advisory circulars will be made to identify material that must be revised to adequately inform airport planners and engineers of the potential requirements of larger aircraft.

Landside Technology

In 1997, guidance on cost/benefit analysis will be prepared to help ensure that Airport Improvement Program funds are efficiently used. Also in 1997, airport access requirements will be developed, followed by publishing an advisory circular on ground access planning in 1999. Technical reports on design considerations for ground access will be published in 2000, and innovations in airport ground access will be demonstrated from 2003-2005.

**Project 051-110: Airport Planning and Design Technology****051-120 Airport Pavement Technology**

**P**urpose: The approximately 650 million square yards of pavement at U.S. airports represent a precious national resource. Replacement value exceeds \$100 billion, and there are only limited practical possibilities for adding to or replacing major pavement systems. Consequently, maximum benefits must be obtained from the existing facilities.

The federal government and the aviation community are spending approximately \$2 billion annually on pavements. There are additional costs resulting from delays due to construction and maintenance. A significant portion of the \$2 billion is spent replacing, repaving, rehabilitating, repairing, and maintaining pavement surfaces. During the next five years, an estimated \$30 billion in federal and local funds will be required to

provide a more efficient and integrated public-use airport system under the FAA's National Plan of Integrated Airport Systems. Of this total, about half will be required for constructing, maintaining, and rehabilitating airport pavements. The majority of this money will be spent at the most heavily used airports carrying the largest aircraft.

The goal of this project area is to reduce the large pavement costs by at least 10 percent by 2010. These savings will be achieved through a systematic research program addressing three areas: pavement design and evaluation, pavement materials and construction methods, and pavement maintenance and repairs.

Specific projects will be carried out to develop an integrated method for pavement design that will reduce pavement design and construction costs, minimize pavement failures, lower the costs of maintenance, and reduce pavement downtime and aircraft delay costs. A new pavement design procedure based on layered-elastic theory has been introduced to support U.S. aircraft manufacturers' efforts to introduce new aircraft. Development of advanced design procedures is currently underway to assure that airport pavement designs will be able to serve new large aircraft. The new methodology supports U.S. efforts in working with the International Civil Aviation Organization towards adopting a revised, internationally accepted basis for determining if airport pavements are compatible with new aircraft designs.

### **Approach:**

#### Pavement Design and Evaluation

Airport pavement design techniques have evolved from the highway design theory developed in the 1920's and extrapolated in the 1940's and 1950's for aviation applications. While this has worked reasonably well in the past, it will not accommodate the dramatic changes associated with new generation aircraft now on the drawing

boards. Research in the technical area of pavement design and evaluation will focus on the development of an advanced design procedure for airport pavements that can be used for both flexible and rigid pavements. As a first step, the FAA has issued a new pavement design standard based on the layered-elastic method to support the introduction of new aircraft. Models to better describe pavement materials and material properties will be developed and incorporated into the advanced pavement design procedure. As part of the development of advanced design procedures, full-scale testing will be performed using the national airport pavement test machine.

To study in-situ behavior and long-term performance of airport pavements, field data of pavement response to aircraft loads and environmental conditions will be collected at major airports by monitoring instrumented runways and taxiways. Research will be conducted to develop criteria and methods for design, evaluation, performance, and serviceability of pavements at airports in cold regions.

#### Pavement Materials and Construction Methods

Research efforts in this area will include: developing methods to specify and use new or improved materials as substitutes for conventional pavement construction materials; identifying factors affecting airport pavement durability; and developing criteria for efficient use of devices, construction materials, and construction techniques.

Studies will be conducted to investigate in-service performance of stabilized-base materials, develop corresponding failure criteria for these materials, and formulate material models that will be implemented in design procedures.

#### Pavement Maintenance and Repairs

Research will be conducted to determine probable causes of significant pavement distress and life-cycle costs.

A new program, the National Registry of New Airport Pavements, will be initiated for organizing long-term data collection on pavement performance. This program will identify new airport construction projects, determine life cycle costs, and quantify other performance factors for all airports included in the data base.

**Related Projects:** 051-110 Airport Planning and Design Technology and 051-130 Airport Safety Technology. Capital Investment Plan projects: F-13 NAS Facilities Occupational Safety and Health (OSH) and Environmental Compliance, F-16 FAA Technical Center Building and Plant Support, F-18 Aeronautical Center NAS Support Facilities, and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- Technical data for pavement design and design life, evaluation, materials, construction, maintenance, and repair
- Software and user guidelines for pavement design and analysis
- National pavement test machine
- Pavement design tools
- National Registry of New Airport Pavements data base

#### **1996 Projected Accomplishments:**

- Complete national airport pavement test machine design.
- Complete pavement response study at Denver International Airport.

**Planned Activities:** Extensive research will continue on design and evaluation standards, materials application, construction technology, and pavement maintenance and repair requirements. Major task components include developing:

pavement design and analysis methodology based on advanced computational techniques; pavement testing and quality control acceptance criteria; specifications for materials; joint sealant criteria; pavement performance data base; and state-of-the-art pavement evaluation techniques.

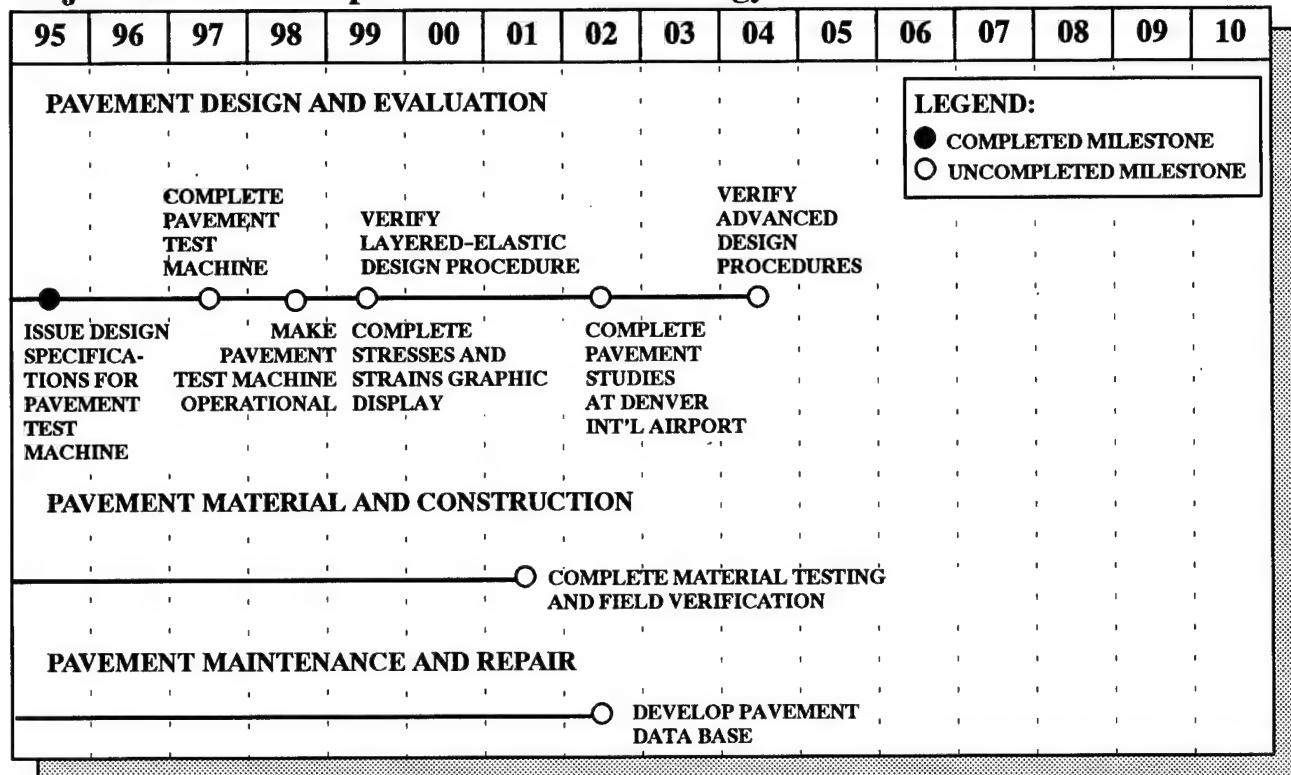
From 1997-2002, a multi-year runway data collection effort will continue at Denver International Airport using sensors embedded in the pavement. These sensors will measure the pavement response and performance to repeated heavy aircraft loading. A data base will be developed to store field-measured data at Denver International Airport. This data will be used to validate pavement design theories. Development of advanced design procedures, field investigation, laboratory testing, and material modeling will be completed in 2001. Full-scale testing will begin in 1997.

Computer software development using the predictive design and analysis methodology will continue in 1997, resulting in a stress/strain graphic display in 1999.

In 1997, work will continue on collecting and analyzing data that relate pavement performance to FAA design and construction standards. This effort will result in a comprehensive airport pavement data base in 2001. Criteria and methods for design, evaluation, performance, and serviceability of pavements at airports in cold regions will be developed.

In 1997, national pavement test machine construction will be completed, and the machine will become operational in 1998. Experiments will be continually run on new materials as they are developed, on new construction techniques, and on pavement lifecycle determination methods. Pavement design tools based on finite element analysis will be completed in 1999. The pavement test machine will be used to conduct various experiments such as verifying the layered-elastic design procedure in 1999 and advanced design procedures in 2004.

## Project 051-120: Airport Pavement Technology



## **051-130 Airport Safety Technology**

**P**urpose: This project will develop new technologies in four research areas: (1) safe and efficient aircraft operations on runway surfaces; (2) new, emerging technologies in lighting, signing, and marking materials for improved visual control systems; (3) new materials, methods, and equipment to improve the capability and cost-effectiveness of airport rescue and firefighting services; and (4) materials, methods, and devices to control birds and wildlife in the airport environment.

### Approach:

## Runway Surface Technology

A critical safety concern at airports is the runway surface condition. Snow, ice, water, and rubber

deposits can result in slipperiness, causing aircraft loss of control during braking as well as making surface movements hazardous. In recent years, grooved runways to control surface water have greatly reduced hydroplaning. However, aircraft accidents from overshooting or veering off contaminated runways remain a problem.

From 1980 to 1991, there were 130 accidents involving aircraft overruns and veeroffs. The accidents involved runway surfaces that were either dry or covered with water, ice, snow, or slush. Major aircraft accidents have focused national attention on the question of runway slipperiness and loss of control during landings and takeoffs. Two recent accidents at La Guardia Airport in 1992 and 1994 identified runway slipperiness

and an inadequate safety area beyond the end of the runway as contributing factors.

The goals of this project are to eliminate by 2000 runway slipperiness as a cause of accidents and develop technologies to safely stop all aircraft within the extent of the runway. To achieve these goals, extensive research, testing, and evaluation will be conducted to develop new techniques, materials, procedures, and equipment to remove ice, snow, and rubber deposits efficiently with minimal adverse environmental impact. Also, research will continue on developing methods to prevent ice and snow accumulation on airport surfaces. In addition, new materials and methods will be investigated to decelerate aircraft safely should there be an overrun.

#### Visual Guidance

Safe and efficient airport ground operations, especially at night and under low visibility conditions, require that pilots and vehicle operators receive conspicuous and unambiguous information from lights, signs, and markings. Improvements in these visual aids will help to eliminate runway incursions.

During the past 15 years, seven air transport surface collisions in the United States have resulted in 17 fatalities and substantial property damage. In 1990, a collision at Detroit International Airport between two aircraft killed eight people. These accidents have brought into focus the need for providing improved visual guidance to aircraft in low visibility conditions.

The goal of this program area is to eliminate by 2000 deficiencies in visual guidance systems and procedures that may contribute to surface collision accidents. This goal will require research efforts in two general areas: visual guidance "control" technology to develop an advanced system for aircraft movement on airport surfaces and developing state-of-the-art light sources and applications. These will include fiber optics, laser sources, and holographic techniques. In

conjunction with this effort, technology will be developed to evaluate new visual guidance systems and procedures, particularly during low visibility conditions, on a computer-based simulation system.

#### Rescue and Firefighting

An analysis of aircraft accidents involving external fuel fires has shown that, although external fires can be effectively extinguished, secondary fires within the fuselage are difficult to control with existing equipment and procedures. Large amounts of smoke, toxic gases, and high temperature levels in the passenger cabin can cause delay in evacuation and pose severe safety hazards. The 1991 accident at Los Angeles International Airport involving two aircraft clearly demonstrated this concern. The rescue and firefighting personnel were faced with a post-crash fuel spill fire, a rapidly growing interior fire, and a structural fire. A rapid response to the accident site was accomplished, but evacuation was hampered by the thick black smoke that filled the cabin following the accident.

The goal of this program area is to increase passenger survival rates in post-crash fires by providing a safe evacuation route from the aircraft cabin in a timely manner. This goal will require research and testing to develop firefighting systems that can effectively be used to control both external and internal cabin fires. New methods, procedures, and firefighting chemicals will be developed for large-capacity aircraft, double-decked aircraft, and/or aircraft made from advanced materials. Research will be carried out to reduce vehicle response during nighttime and low visibility conditions, and to develop new training techniques for rescue and firefighting personnel. Improvements in response times and proper equipment development are needed for operations in poor visibility conditions.

Improvements in soft terrain and off-road firefighting vehicle capabilities will be needed to cope with expanded airport runway

configurations into 2000 and beyond. Reductions in off-runway response times will be achieved by developing a new truck suspension system that improves traction in soft sand and wet/uneven ground conditions.

Chemicals used in airport firefighting are raising concerns about environmental damage. Research will investigate methods to maintain a high level of performance for firefighting services while minimizing air pollution and ground water contamination. This work will include developing environmentally friendly extinguishing agents such as agents that will aid in the cleanup of a large post-crash fuel spill.

#### Wildlife

Wildlife presence at or near airports poses a potential threat to movement of aircraft and other ground vehicles. In spite of various control devices in use to keep birds away, over a thousand bird strike incidents are reported every year. Many more incidents are known to occur, but are not reported.

Since 1912, when the first fatal accident of a Wright Flyer was recorded, 104 civil aviation fatalities from bird strikes have been reported in the United States. Worldwide civil aircraft fatalities total approximately 126, and the potential for a serious accident continues. Bird strike damage cost has been estimated at \$1 billion annually by the Europe Bird Strike Committee.

The goals of this program are to increase airport safety and decrease damage to aircraft by reducing bird strikes. These goals require research efforts in developing effective regional wildlife habitat management to minimize or eliminate sources of bird attraction at airports. A computer data base compiling annual U.S. bird strike reports was added as a component of this research project in 1995 to provide data on this significant

aviation statistic. Research will also be conducted to identify active and passive harassment techniques that can effectively control the presence of birds and other wildlife at airports. These techniques and methods will assist airport owners and operators in complying with FAA airport certification regulations. Land use siting compatibility guidance will be provided by researching relationships among birds, airports, and landfills.

**Related Projects:** 022-140 General Aviation and Vertical Flight Program, 051-110 Airport Planning and Design Technology, 051-120 Airport Pavement Technology, 061-110 Aircraft Systems Fire Safety, and 067-110 Fire Research. Capital Investment Plan projects: A-12 Airport Surface Target Identification System (ATIDS), F-13 NAS Facilities Occupational Safety and Health (OSH) and Environmental Compliance, F-16 FAA Technical Center Building and Plant Support, F-18 Aeronautical Center NAS Support Facilities, and N-04 Visual Navaids.

#### **Products:**

- Technical data supporting rules, regulations, and advisory circulars on runway surface maintenance
- Design specification for low-cost mobile firefighting live-fire training facilities
- Technical data and design criteria for lighting and marking systems for airports, heliports, and vertiports
- Technical data on tests and evaluation of firefighting agents, full-scale systems, and rapid response, all-terrain firefighting vehicle
- Technical publications, data, and advisory circulars on wildlife habitat management, bird harassment techniques, landfill studies, and annual U.S. bird strike reports

## **1996 Projected Accomplishments:**

- Publish report on prototype soft ground arresting system installation at JFK International Airport.
- Publish technical report on electrically conductive asphalt pavements.
- Publish technical report on experimental infrared aircraft deicing system.
- Publish specifications for improved taxiway holding position lights.
- Publish study for identification of key components for an advanced visual guidance system.
- Provide data on simulation study for the potential redesign of approach lighting systems.
- Develop advisory circular for firefighting response in Category IIIC poor visibility weather conditions.
- Approve an alternative 3-dimensional running fuel fire extinguishing agent to ozone-damaging Halon 1211.
- Develop specifications for generic designs for fixed and mobile live-fire training facilities to be included in advisory circular 150/5220-17A Design Standards for an Aircraft Rescue and Firefighting Training Facility.
- Develop training criteria for annual live-fire training for airport firefighters.
- Publish first U.S. bird strike report, fifth report on wildlife harassment/deterrent techniques for airports, and third report on landfill studies.

- Complete first regional wildlife habitat management study at Atlantic City International Airport.

## **Planned Activities:**

### Runway Surface Technology

In 1997, a final report will be completed on innovative ice prevention/removal techniques, leading to an advisory circular in 1998.

In 1997, standards will be issued for airport soft ground arresting system design and installation. In 1998, development work will begin on updating these standards for new transport aircraft and arresting materials. These standards will be updated by 2005 to accommodate the new, large, wide-body aircraft.

In 1997, research will investigate methods for removing rubber deposits from runways while maintaining pavement integrity. By 1998, guidance will be issued on ways to optimize rubber removal without reducing pavement life.

### Visual Guidance

In 1997, work will continue on developing an advanced visual guidance system that controls and guides aircraft taxiing to and from the runway in low visibility conditions. In 1998, a prototype system will be evaluated, leading to standards in 2000.

In 1997 through 2002, advanced technology lighting sources will be evaluated for potential inclusion in more efficient airport and approach visual guidance systems. Fiber optic and more efficient light sources for approach and airport lighting use will be evaluated at the FAA Technical Center in 1997, followed by field prototype and evaluation in 1998, with standards issued in 2000.

## Rescue and Firefighting

In 1997, work will continue on evaluating strategies for attacking post-crash fuel fires on new, multi-level, high density seating, passenger aircraft. Elevated waterways and boom penetration devices will be used to provide increased passenger evacuation protection for aircraft having five hundred or more passengers. Also in 1997, work will continue on developing training requirements as well as operational strategies for firefighting response at airports conducting operations to zero zero weather conditions. Also in 1997, work will continue on providing fire truck crews with information for efficient movement on the airport and rescue operations following a crash. Efforts will continue on evaluating the rescue firefighting standards against requirements to control and extinguish fires in aircraft containing composite material.

In 1997, an evaluation will be continued for aircraft rescue and firefighting training simulators. A study will begin on a model, full-scale firefighting training facility that meets both environmental concerns and operational requirements. Based on this research, the current training advisory circular will be updated in 1998 for a standardized, model firefighting training simulator. In addition, a performance standard will be established that measures firefighter training efficiency using propane simulators versus real hydrocarbon fuel training.

In 1997, the current fire protection advisory circular will be updated to include new-generation transport aircraft, such as the Boeing 777. It is expected that the advisory circular will be updated in 2000 to include fire protection for aircraft in the 600-800 passenger capacity and in 2006 to include aircraft up to 1,000 passengers. In the 2005-2010 timeframe, research will be

conducted on fire protection requirements for future high-speed civil transports.

In 1997, an advisory circular will be published to address technologies that deal with firefighting procedures for advanced composite aircraft and structures

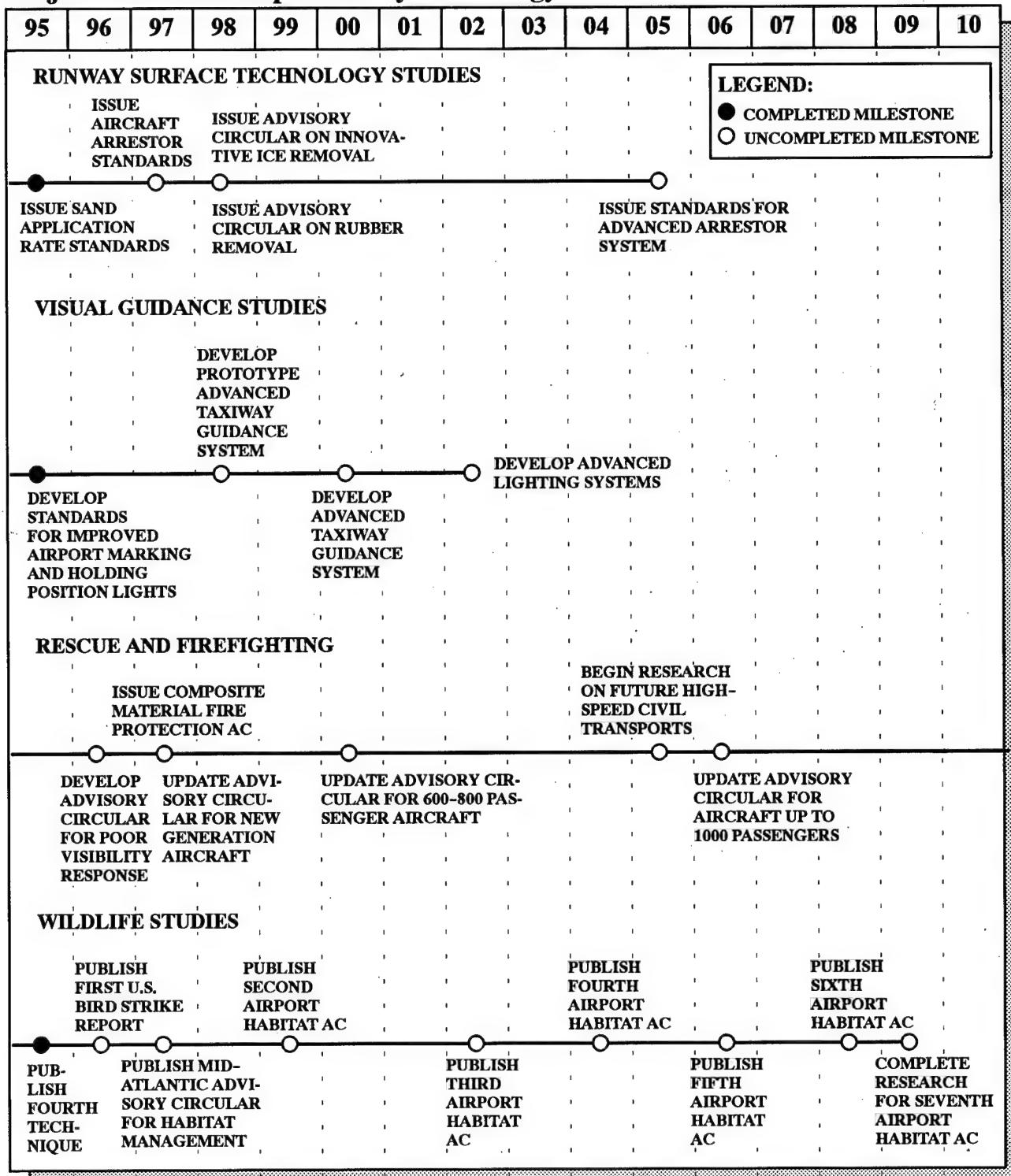
## Wildlife

In 1997, the second regional airport habitat management study at O'Hare International Airport will continue. Research on a fifth wildlife harassment/deterrent technique and landfill studies will also continue.

A Mid-Atlantic U.S. advisory circular will be completed in 1997, based on the 1996 Atlantic City habitat study. The third regional habitat study will begin in 1998 and conclude in 2002. A final report on the sixth wildlife harassment/deterrent technique will be finished in 1997. Regional habitat management studies will be initiated and completed every 2 years until the 10 regional studies are finished. These regional airport studies will continue through 2008, with advisory circulars published 1 year after final reports. In 1997, the second annual U.S. bird strike report will be published. Also in 1997, landfill studies will continue as scientific evidence describes the link between gull populations and solid waste facilities as well as their effects on airports and aircraft traffic.

The primary thrust of the wildlife research efforts is to identify and document the effectiveness and applicability of new wildlife habitat management and harassment/deterrent techniques for use on or near airports to mitigate bird and wildlife hazards. Knowledge of bird relationships to existing and new solid waste facilities will establish a sound scientific basis to evaluate potential bird attraction effects on or near airports.

# Project 051-130: Airport Safety Technology



## 6.0 AIRCRAFT SAFETY TECHNOLOGY

Today's passenger safety depends on fault-free maintenance and operation of the Nation's civil aircraft. Tomorrow's passenger safety depends on steps taken now to ensure future aircraft reliability and their operator's competency. The steps taken today by the FAA for future safety are embodied in the Aircraft Safety Technology Program. This program addresses the many hazards that face all aircraft in flight, as well as special hazards endemic to select portions of the civil aircraft fleet. Older aircraft are more susceptible to structural problems associated with fatigue and corrosion. New aircraft, with their digital flight control and avionics systems and associated imbedded software, are more susceptible to upset from external electromagnetic interference. The main hazards the FAA Aircraft Safety Research Program addresses are represented in Figure 6.1.

Aircraft safety improvements will reduce fatalities and injuries, reduce hull losses, improve aircraft designs, and impact maintenance and inspection procedures. Each project in this thrust area has the potential to provide significant benefits. For example, more efficient nondestructive airframe testing could produce \$40 million per year in benefits. A similar improvement in engine maintenance efficiency could achieve \$20 million per year in benefits. An additional \$30 million per year could accrue from these two projects due to using more effective inspection techniques and avoiding major engine failure incidences.

Research in aircraft fire safety has the potential for accruing large benefits. Statistics show the United States has about 30 to 35 fire fatalities per year in otherwise survivable accidents, and about

135 fatalities worldwide. At an estimated cost of \$1.5 million per life, saving 3 people per year would pay for the entire fire safety research, engineering, and development effort.

Over the past 20 years, the aircraft accident fatality rate has been nearly level at just under two deaths per 10 million passengers carried. This statistic is a tribute to aircraft safety provided by the designers, operators, and regulators. Because the civil fleet's size increased over this period, the leveling fatality rate translates into an increase in total fatalities. These statistics indicate that new safety problems have been arising as old ones have been eliminated. Further, some safety problems such as fire and crashworthiness have continued to persist. Other potential problems, such as flight critical software-based digital fly-by-wire flight control systems, have not had sufficient operational exposure.

Maintaining the good safety record over the past two decades has required introducing new safety technologies, such as cabin floor emergency escape lighting and seat fire blocking layers. Such enhancements are in addition to scores of pre-existing safety requirements for aircraft. Examples include design requirements for the aircraft structure so occupants can survive rapid decompression at cruise altitudes and demonstrations proving that all cabin passengers can evacuate within 90 seconds for each newly certificated transport category model. The most important purpose of FAA aircraft safety research is to develop technical requirements for safety improvements needed to maintain or improve the safety level in an evolving aviation environment.

# Aircraft Safety

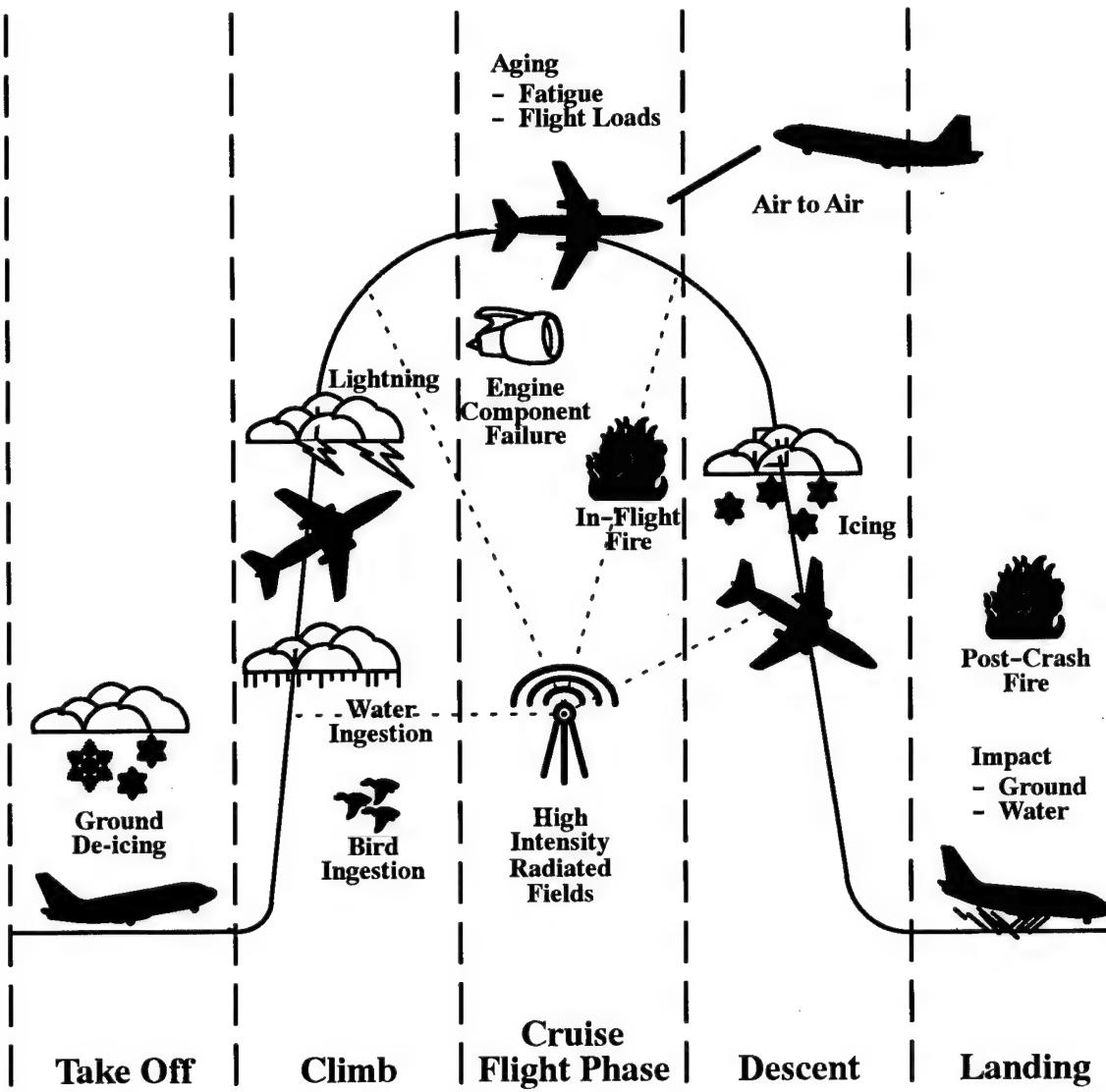
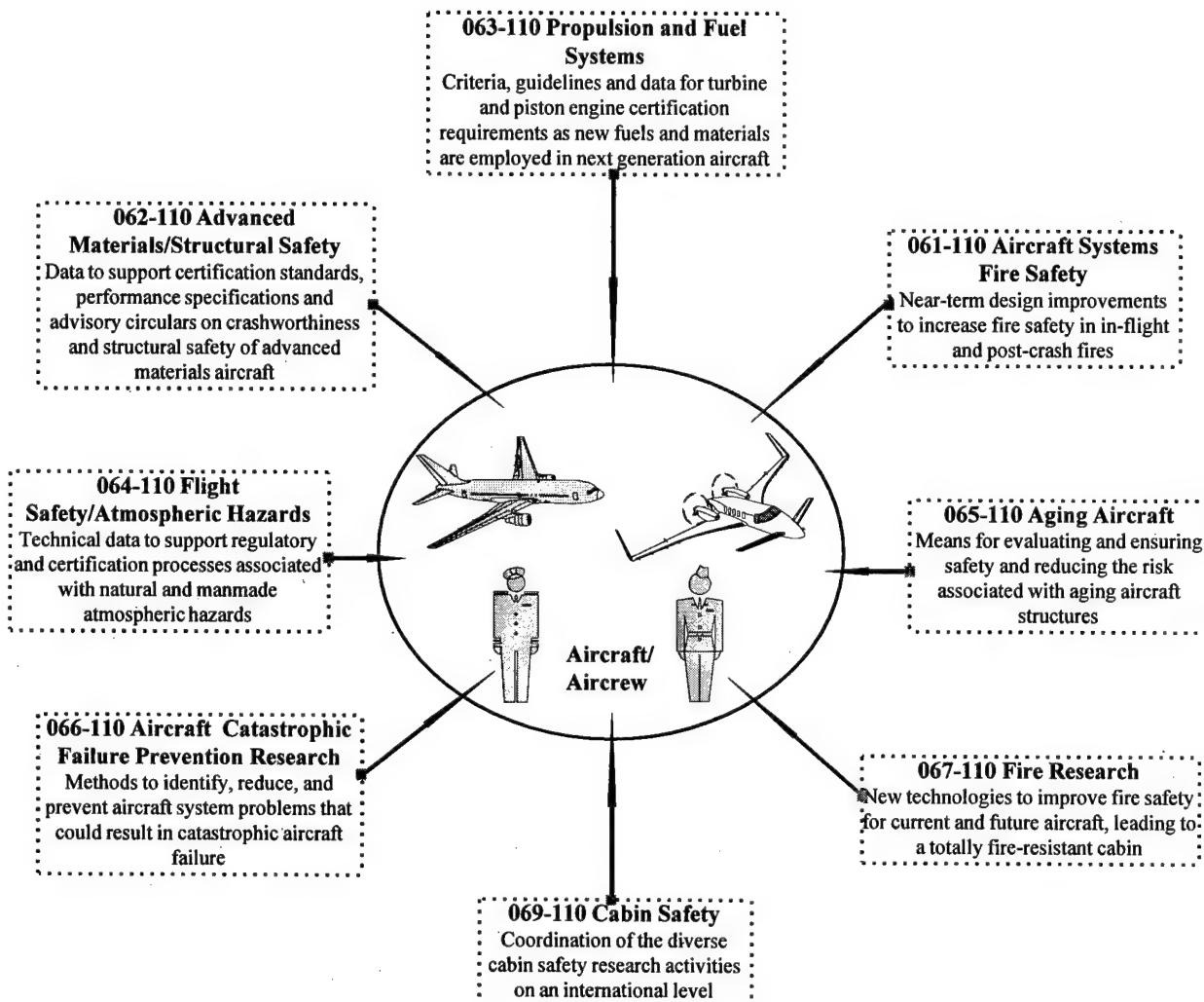


Figure 6.1 Typical Flight Hazards

## Aircraft Safety Technology Projects

### Contributions to FAA Services



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## 6.1 Aircraft Safety Technology Project Descriptions

### 061-110 Aircraft Systems Fire Safety

**P**urpose: This project will minimize fire-related injuries and increase survival rates for aircraft occupants during in-flight and post-crash fires. It provides near-term products to improve the fire safety design of aircraft interiors, primarily commercial transports. In-flight fire safety improvements will be developed to prevent the ignition of interior materials or, if a fire should occur, to rapidly and reliably detect and control the fire until the airplane can be safely landed at the nearest airport. With respect to intense post-crash fires, the goal is to develop design improvements that reduce the cabin fire hazards that prevent passenger escape, including heat, smoke and toxic gases. The project will also develop design improvements that increase passenger evacuation rates.

**Approach:** Aircraft fire issues are unique when compared to fire safety issues in buildings, residences, and ground transportation. Fire safety advancements in aircraft will continue to rely heavily on testing, evaluation, and development, and this project will utilize the unique aircraft fire test facilities at the FAA Technical Center to develop design improvements. In particular, the Full-Scale Fire Test Facility, the U.S. government's largest, will be employed to simulate realistic post-crash and in-flight fires in order to define fire problems, evaluate improvements, and develop design requirements. This real-world full-scale testing approach has been successful in the past, leading to major improvements in aircraft fire safety mandated by the FAA through the rulemaking process.

This project is comprised of three general areas: materials fire safety, fire management, and systems. Fire problems in specific aircraft applications will be solved or ameliorated using the best existing fire technology determined by the full-scale testing approach.

#### Materials Fire Safety

Laboratory fire test criteria are the certification basis employed by the FAA to approve aircraft interior materials for fire safety performance. Depending on the fire threat and material application, a test method measures some desirable performance characteristic of a material when subjected to a fire. For example, a cargo liner is evaluated on the basis of fire burnthrough resistance in order to protect other parts of the aircraft against in-flight cargo fires. All FAA-required fire test methods are validated by using full-scale fire test results.

The first task under this activity will provide data which could be used in design guidelines for hardening aircraft fuselages against burnthrough by an external post-crash fuel fire. Analyses of aircraft crash fires indicates that the fuselage is intact in 50% of accidents, yet there are no standards that address fuselage burnthrough resistance. Materials and components which will be tested for improved burnthrough resistance include thermal-acoustical insulation, windows, honeycomb sidewall panels, and air return grilles.

The second task involves the development of fire test methods for cabin and structural materials in future aircraft designs such as the high-speed civil transport (HSCT) and large capacity, double-decked airplanes, called very large commercial transports (VLCT). With respect to the HSCT the primary focus will be on the composite fuselage skin. Full-scale tests will be conducted on aircraft fuselages employing composite skins to determine the hazards associated with exposure to a post-crash fuel fire. These hazards include smoke and toxic and combustible gases accumulating within the cabin. The goal is to reduce the impact of these hazards on passenger

evacuation. In the VLCT the vulnerability of the upper deck to a post-crash fire, the chimney effect, is a major concern. Fire stops designed to inhibit the spread of fire into the upper deck, protection of floor beams to assure integrity of the upper floor during the evacuation process, and the adequacy of current fire test criteria for cabin materials will be evaluated. A double-decked fuselage testbed will be constructed to examine each issue and develop design improvements.

The final task harmonizes and improves the standardization of existing fire test methods required by the FAA and foreign airworthiness authorities. This effort is accomplished by an International Aircraft Material Fire Tests Working Group, chaired and administered by the FAA. Activities include resolving discrepancies between laboratories, simplifying test procedures to reduce the cost of testing, addressing unusual material behavior, and improving the calibration of test devices.

### Fire Management

Fire management refers to active systems designed to detect and extinguish or suppress fires in aircraft. The FAA requires fire management systems in areas of the aircraft that may be vulnerable to fire. For example, fire detection and extinguishing systems are mandated in large cargo compartments because of the potential flammability of freight and luggage. Near-term improvements in fire management are related to the reliability and responsiveness of smoke/fire detectors, and the effectiveness of fire extinguishing systems.

The first task under this activity is to conduct tests which will lead to revised certification criteria to approve new fire extinguishing agents as effective as Halons. Production of Halons ceased on January 1, 1994, by international agreement, because of their contribution to the depletion of the ozone layer. Halons are currently used in aircraft fire extinguishing systems; however, with the diminishing availability and high costs of

recycled Halon, new agents are being developed and need to be tested by FAA to determine their effectiveness. Industry participation and harmonization with foreign airworthiness authorities is obtained through the International Halon Replacement Working Group, chaired and administered by the FAA.

The second task involves the development of a cabin water spray fire-suppression system to improve passenger survivability during post-crash fires. Past FAA full-scale fire tests demonstrated that water spray was extremely effective in contemporary cabin designs. The double-decked fuselage testbed will be employed to evaluate the effectiveness of water sprays in very large transports such as the VLCT, carrying 800-1000 passengers, where the potential for fire fatalities is far greater.

The final task will be to develop a standardized test procedure to certify cargo compartment fire/smoke detectors. No standards exist, and it is likely that the level of safety varies for different FAA-approved detectors. Past FAA tests have shown that the theatrical smoke now used to certify detectors provides an overly optimistic detector response rate. As a result, more realistic smoke simulants are needed.

### Systems

Malfunction or damage to vital aircraft systems may cause fires or accelerate the spread of fire. Emphasis will be placed on emergency oxygen systems because these systems are the most likely to cause or accelerate aircraft fires. Based on a review of accidents, incidents, and service problems, full-scale tests will be conducted on aircraft oxygen systems to identify near-term design changes that can eliminate or reduce oxygen-fed fires.

**Related Projects:** 051-130 Airport Safety Technology, 062-110 Advanced Materials/Structural Safety, 063-110 Propulsion and Fuel Systems, 067-110 Fire Research, 069-110 Cabin Safety, and 086-110 Aeromedical Research.

Capital Investment Plan projects: F-16 Technical Center Building and Plant Support and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

**Products:**

- Upgraded aircraft material fire test handbook
- Harmonized and improved standardization of material fire test methods
- Upgraded fire performance criteria for aircraft cabin materials in future aircraft designs
- Requirements for approving Halon-alternate extinguishing agents
- New fire test standards for hand-held extinguishers and lavatory extinguishers
- Cabin water spray system design for large, double-decked aircraft
- Data for improved fire hardening for fuselage structures
- Fire-safe emergency oxygen system improvements
- Data to support new certification test standards for cargo compartment detectors

**1996 Projected Accomplishments:**

- Evaluate environmentally acceptable gaseous agents as replacements for Halon 1301 in cargo compartment fire suppression systems.
- Develop minimum acceptable levels of performance and criteria for Halon 1211 replacement hand-held extinguishers.

**Planned Activities:**

Materials Fire Safety

In 1998, design guidelines will be developed for hardening aircraft fuselages against burnthrough by an external post-crash fuel fire. Approval of fuselage materials and components will be based on a laboratory burnthrough test that has been validated by full-scale fire tests. From 1999-2000, research will be conducted to examine the need for fire test procedures for the composite fuselage skin planned for the HSCT. If research determines that hazardous gases are produced from the composite skin during fuel fire exposure, testing procedures will be developed by 2000.

In 1998-2002, research will be conducted to develop fire safety measures and improved fire test requirements for cabin materials in future double-decked aircraft designs such as the VLCT. A full-scale double-decked fuselage testbed will be constructed in 1998. In 1999 full-scale fire tests will be conducted to characterize fire spread into and within the vulnerable upper cabin. These data will be used to evaluate and develop fire stops, improved floor strength, and improved cabin materials fire performance in 2000-2001. In 2002, final design criteria, including fire test requirements, will be developed for the VLCT.

Efforts to resolve agency certification issues related to material fire test requirements will be supported by continuing to sponsor and conduct the International Working Group on Aircraft Material Fire Tests.

Fire Management

In 1997, based on previously completed full-scale fire tests, minimum acceptable levels of performance and criteria will be developed for Halon 1301 replacement agents in cargo compartment fire suppression systems. Also, engine nacelle fire extinguishing tests will

commence on first-generation replacement agents such as hydrofluorocarbons and hydrochlorofluorocarbons approved by the Environmental Protection Agency. Engine nacelle tests on second generation agents such as trifluoromethyl iodide will be conducted in 1998. Also in 1998, the test results will be used to develop engine nacelle certification criteria for approving replacement agents with equivalent effectiveness to Halon 1301.

Cabin water spray research will focus on fire protection in the upper deck of the VLCT. In 2000-2001, full-scale fire tests will be conducted to develop and evaluate a water spray system. In 2002, the test results will be employed to trade off the relative effectiveness of cabin water sprays and improved fire resistant materials during a post-crash fire.

In 1999, tests will be conducted on representative FAA-approved cargo compartment smoke detectors under both flaming and smoldering fire conditions. These tests will evaluate detector response time and sensitivity. Based on this analysis and other relevant compartment parameters,

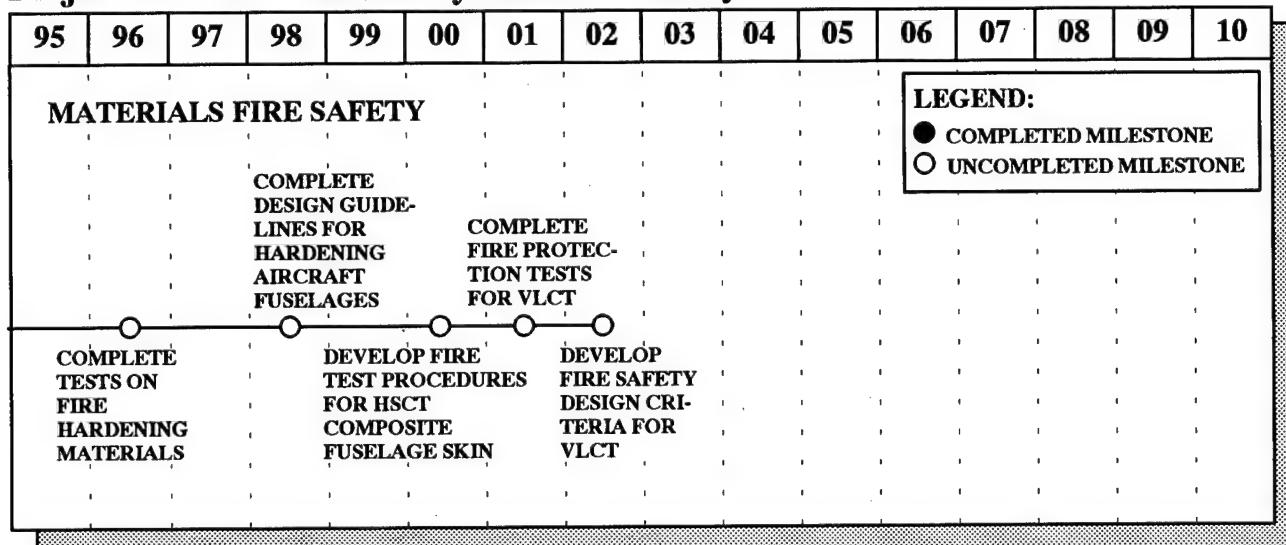
a standardized certification test procedure will be developed in 2000 that measures detector response rates for compliance with existing regulations.

### Systems

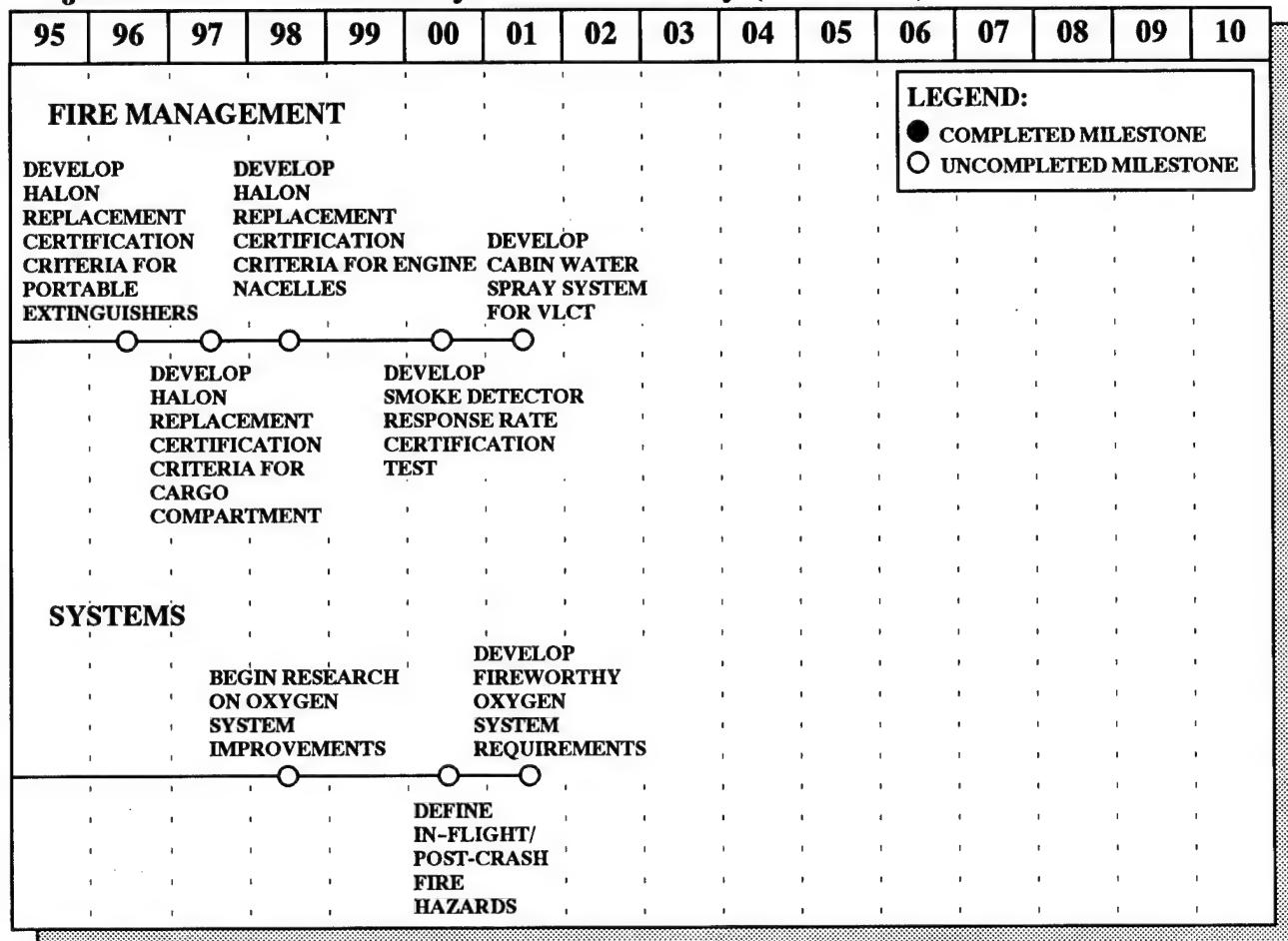
In 1998, work will begin on evaluating the hazards associated with fires initiated or intensified by emergency oxygen system malfunctions/failures. Actual oxygen systems, including both compressed oxygen and oxygen-generating canisters, will be tested in 1999-2000 to define in-flight fire and post-crash fire hazards. Improved installations, protective measures, and possible system redesigns will be tested and evaluated in 2000-2001. The goal is to develop requirements for fireworthy oxygen system improvements by 2001.

In 1997, support for National Transportation Safety Board aircraft fire investigations will continue, including participation on accident investigation teams, accident material and fluid chemical analysis, and full-scale fire tests to recreate/analyze accident scenarios.

### Project 061-110: Aircraft Systems Fire Safety



## Project 061-110: Aircraft Systems Fire Safety (continued)



## 062-110 Advanced Materials/Structural Safety

**P**urpose: This project addresses concerns in two major areas. The first area is advanced materials research, which because of a lack of information and standards on composites and other advanced materials, will focus on acquiring the necessary knowledge to support certification and airworthiness regulations. In addition, this project will support other government agencies in general aviation renaissance research and foster usage of advanced materials in airframes and engines. The second area addresses crashworthiness structural safety and ways to increase protection for both occupants and crew during an accident. Research will be conducted to develop

and validate test procedures necessary for generating required data. These data are needed to support certification standards, performance specifications, advisory circulars, and other regulatory materials necessary to enhance aircraft crashworthiness and occupant safety.

### Approach:

#### Advanced Materials

Research will focus on technology issues identified in the Aircraft Advanced Materials Research and Development Plan which has been

coordinated with the National Research Council of the National Academy of Sciences' findings. Management of this technical effort is accomplished by focusing on three technology task areas: materials standardization and test methods, structures, and handbook development. The materials area will investigate the mechanical properties of composite and other advanced materials. The structures area will investigate reliability design, damage tolerance, joints, and other structural or fatigue concerns. Handbooks useful to the FAA, other government agencies, and industry personnel, containing information on design, analysis, inspection, and failure analysis of composite materials will be produced. The data generated in the three tasks will be used by FAA personnel and will form the basis for rule-making, advisory circulars, and training, and by industry to introduce advanced materials into new designs.

These research efforts will be accomplished in part via the Aviation Research Grant Program, interagency agreements, memorandums of understanding, and the Small Business Innovative Research Program.

### Structural Safety

This project establishes a technical data base to generate structural airworthiness and aircraft crashworthiness criteria for both fixed-wing and rotary-wing aircraft. Experimental and analytical research efforts will be developed to create guidelines and performance criteria that ensure continued aircraft structural airworthiness. These efforts will help reduce occupant injuries and fatalities during a crash.

Aircraft crashworthiness includes three areas: airframe structures, aircraft interior, and analytical modeling/computational methods. The airframe structures area will analyze the crash environment, aircraft fuel systems, and structural components to identify and address structural failures. The aircraft interior area will analyze

seat/restraint systems and interior furnishings. Analytical modeling/computational methods will be used in developing improved structural, occupant, and seat/restraint systems.

**Related Projects:** 061-110 Aircraft Systems Fire Safety, 063-110 Propulsion and Fuel Systems, 065-110 Aging Aircraft, 066-110 Aircraft Catastrophic Failure Prevention Research, 067-110 Fire Research, 069-110 Cabin Safety, and 086-110 Aeromedical Research. Capital Investment Plan projects: F-16 Technical Center Building and Plant Support and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

### **Products:**

- Handbooks for FAA personnel on new composite technologies and manufacturing/inspection analysis techniques
- Composite component design based on reliability assessments
- Assessment of mechanical property test methods
- Data package on damage tolerance for structures constructed using advanced materials
- Data package addressing certification criteria for seat/restraint systems
- Technical data packages on crash-resistant fuel system designs
- Data package and analysis of rotorcraft exposed to a water impact environment
- Integrated crashworthiness analytical modeling program between the FAA and the United Kingdom
- Data base and methodology for applying damage tolerance analysis in rotorcraft certification

- Methods for determining critical rotorcraft components and principal structural elements and techniques to monitor their operational health

#### **1996 Projected Accomplishments:**

- Generate material design values for general aviation research.
- Publish material on composite joints in Military Handbook 17.
- Develop computer program for reliability assessment of composite aircraft structures.
- Establish delamination growth thresholds for complex structural details.
- Update Fiber Composite Analysis and Design Handbook and Handbook on the Manufacture and Inspection of Composites.
- Complete data base for damage tolerance of flat and curved panels.
- Complete vertical drop testing of a Beechcraft 1900 commuter aircraft fuselage to determine structural dynamic loads.
- Establish coordinated crashworthiness analytical modeling program between the FAA and the United Kingdom.
- Complete composite material modified aircraft vertical drop test at the National Aeronautics and Space Administration (NASA).
- Complete data base sufficient to establish the minimum requirements for health and usage monitoring systems (HUMS) for rotorcraft.

#### **Planned Activities:**

##### Advanced Materials

Further assessments of design based on reliability methods will continue with a goal to publish guidelines in 1999. Work will also continue on the following: studying damage accumulation in composites from repeated loads to establish test protocols for aircraft certification with completion by 1998; and developing analytical modeling for composite structure delamination with completion in 1997. This research will be used to assess damage tolerance of composite fuselages by 2001.

In 1997, research on a refined 3-dimensional analytical model that predicts the response and failure of bolted composite joints will continue with completion in 1998.

In 1998, the investigations for new materials/forms and the high-speed civil transport research will begin, continuing through 2007. Intermediate milestones in 2003 will be to develop test methods for higher temperature materials and establish certification guidelines for aircraft parts constructed from new materials/forms using automated equipment. The fabrication processes include textiles such as 3-dimensional braiding, resin transfer molding, and stitching. A high-temperature materials data base will be assembled in 2005 for use in HSCT certification in 2007.

Composite handbooks require periodic updates. In 1997, the Design and Analysis Handbook will be updated, followed in 2001 by the Failure Analysis Handbook. All handbooks will be updated in 2005.

## Structural Safety

A preliminary analysis related to commuter aircraft structures will be completed in 1997. Also in 1997, a vertical drop test will be conducted on a Shorts 330 which represents a typical metal 30-passenger commuter aircraft. Testing will be completed in 1997 on a commuter aircraft that utilizes composite materials. This testing will be accomplished through an interagency agreement with NASA.

In 1997, a vertical drop test will be completed on a conformable auxiliary fuel tank. In 1998, an auxiliary fuselage fuel tank system analysis will be completed to develop recommendations for guidelines. Empennage and fuel tank analyses will be completed in 1999. In 2002, tests and evaluations of crash resistant fuel systems will be completed.

Overhead bin testing for various transport category aircraft configurations will continue through 1997.

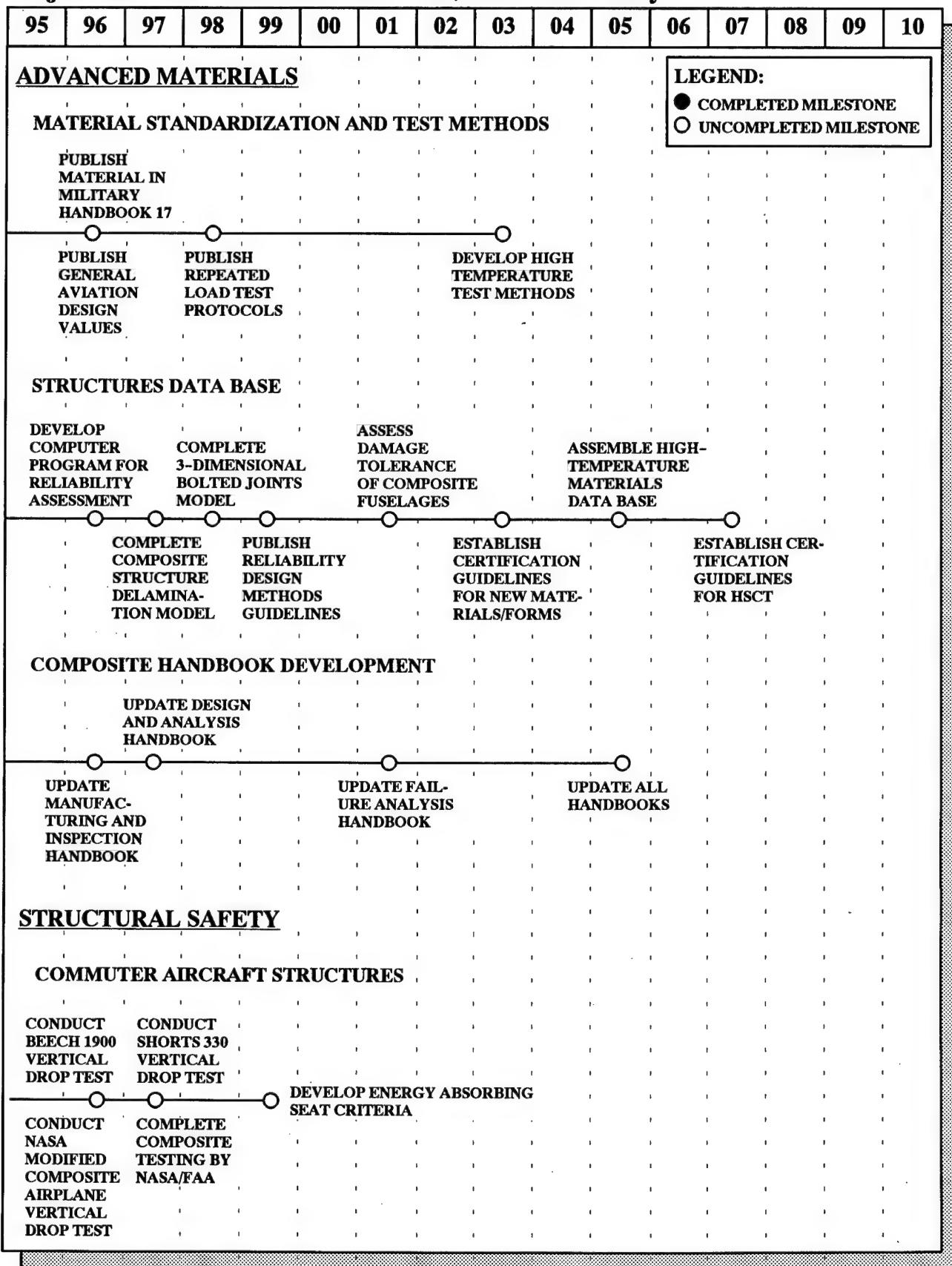
In 1997, testing associated with various commuter cabin safety issues will continue. Data collected from previous drop tests will be used to improve seat designs and models. Energy-absorbing seat criteria will be developed in 1999.

In 1997, work will continue on an air accident investigation tool (AAIT). An updated prototype version AAIT will be developed in 1998 with a completed system in operation by 2002. This effort will complete the joint FAA/United Kingdom research program.

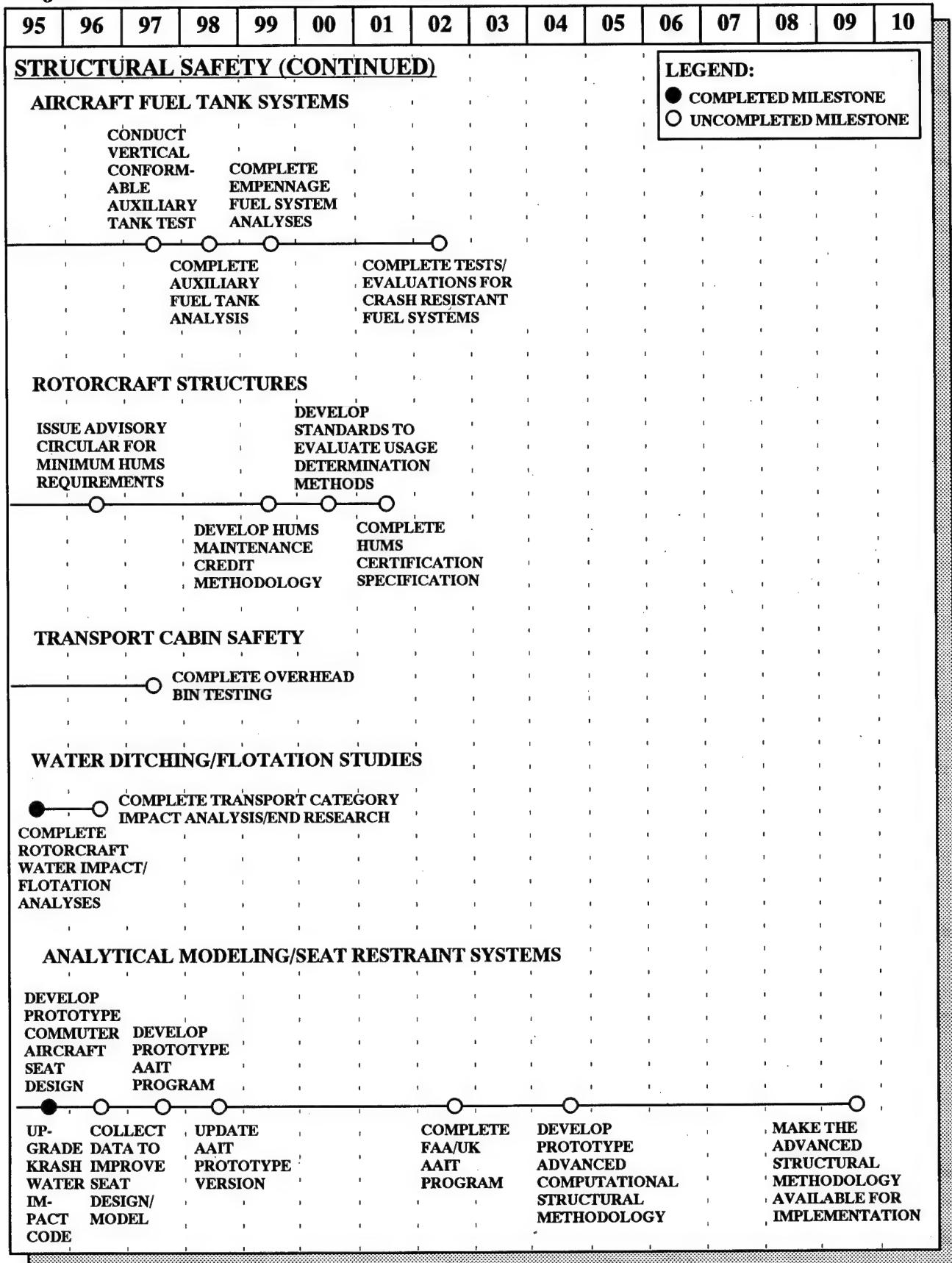
In 1997, work will continue on the development of a cockpit air bag restraint system which can be used in both rotary- and fixed-wing aircraft. Work will also continue on the development of health and usage monitoring systems to determine optimal inspection/replacement intervals. Efforts to incorporate HUMS into the rotorcraft fleet will continue in 1997. The HUMS maintenance credit methodology to establish inspection/replacement intervals will be developed by 1999. In 2000, standards to evaluate usage determination methods will be developed, with HUMS certification specifications completed in 2001.

In the 2000-2004 timeframe, concept development and analyses will be conducted to develop an advanced replacement for the current analytical computer model. By 2004, an advanced computational structural methodology prototype will be developed to undergo evaluations through 2007. Data obtained from these evaluations will be used to refine the methodology and make it available for implementation by 2009.

## **Project 062-110: Advanced Materials/Structural Safety**



# Project 062-110: Advanced Materials/Structural Safety (continued)



## 063-110 Propulsion and Fuel Systems

**P**urpose: This project will address safety issues as new fuels and materials are employed in the next generation aircraft. Super-alloys, ceramics, and coatings will permit the engines of the 1990's and beyond to operate at higher temperatures and pressures. However, future engine reliability is a concern as thermal and mechanical fatigue/fracture problems are likely to become more serious. Additionally, environmental and economic issues will force a change in fuels used to power civil aircraft. Performance, safety, and reliability issues will be affected by the transition to these new fuels. This project will provide FAA certification and flight standard offices with the data needed to generate new standards and will develop a data base for industry use to aid in transitioning to the future technologies.

**Approach:** This project develops criteria, guidelines, and data to support improvements in turbine and piston engine certification requirements. The primary research and development areas are engine reliability, engine structural safety, and future fuels/safety.

### Engine Reliability

Analyses will determine if current standards adequately address engine reliability problems under extreme operating temperatures and pressures. Advanced engine safety and reliability will be continuously assessed as these engines are developed for future transport and general aviation aircraft.

Research is being conducted to develop technology and establish a technical data base for turbine engine rotor inspection methods during production and in service.

The current maturity of digital engine controls and digital flight data recorders, coupled with dramatic advances in the capabilities of portable

micro-computers, software, and sensors, provide the basis for the development of low-cost, yet sophisticated, monitoring tools for commercial aircraft operators. The approach will be to develop and apply systems to predict turbine engine rotating component failures and monitor operational history. The system will be able to acquire, calculate, and interpret temperatures, pressures, speeds, fuel flow, vibration, exhaust, oil analysis, air data, nondestructive inspection data, maintenance actions, and critical life usage. From this information, the system will provide appropriate crew notification, analysis display, maintenance documentation, parts life management, maintenance trouble shooting, and failure diagnostics.

### Engine Structural Safety

To address turbine rotor structural integrity, an enhanced rotor material design and life methodology will be developed. This research program features the development of a probabilistically based damage tolerant design tool to augment the commercial aircraft engine safe-life management philosophy. This general purpose design code features a generic interface for the design codes used by the engine manufacturers. The probabilistic code will enable preliminary design analyses including risk and reliability sensitivities. The software and data will be transferred to industry through software documentation, program reviews, and a training workshop.

Current production methods for the titanium alloys used to fabricate critical rotating components can produce metallurgical defects that can compromise the structural integrity of the finished part. In conjunction with improvements in the current production and inservice nondestructive inspection techniques to detect the defects, the FAA plans to accelerate the development of an advanced technology to produce titanium alloys that are free of metallurgical defects.

## Future Fuels/Safety

The unleaded aviation gasoline development effort is part of a joint industry-government research program managed by the Coordinating Research Council. The FAA leads the Council's High Octane Unleaded Aviation Gasoline Group. Participants in the program include fuel producers, engine and airframe manufacturers, and user groups. The FAA also participates in the American Society for Testing and Materials task groups that are developing a high octane unleaded aviation gasoline specification and an 82 octane unleaded aviation gasoline specification.

Data will be generated on using unleaded gasolines in aircraft piston engines through ground-based testing, flight tests, and laboratory studies. Specific concerns include: engine performance, fuel consumption, engine knock, hot fuel certification, material compatibility, engine durability, and exhaust emissions. Factors that affect aviation fuel availability will be monitored and research initiated as needed to address both safety and reliability concerns. The results from a previously completed fuel risk assessment will be used to evaluate promising approaches for improving post-crash fuel containment on transport category aircraft. A future study will investigate the effects of elevated fuel temperatures expected on high-speed civil transports.

**Related Projects:** 061-110 Aircraft Systems Fire Safety, 062-110 Advanced Materials/Structural Safety, 065-110 Aging Aircraft, and 066-110 Aircraft Catastrophic Failure Prevention Research. Capital Investment Plan projects: F-16 Technical Center Building and Plant Support and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

### **Products:**

- Improved engine rotor durability assessment methods
- Probabilistic engine rotor design code

- Prototype engine diagnostic system hardware and software
- Improved turbine rotor nondestructive inspection standards
- Manufacturing specification for titanium production
- Recommendations for certification standards on general aviation fuels
- Procedures and software for industry use on octane requirements and engine knock characteristics
- Data on fleet octane requirements and materials found in existing aircraft, including aircraft whose manufacturers are no longer in existence
- Simplified and updated crash resistant fuel systems component test standards to reduce industry certification burden
- Design performance criteria associated with cost effective fuel tank bladder and other crash-resistant fuel tank components

### **1996 Projected Accomplishments:**

- Develop performance criteria for turbine engine rotor and onboard failure diagnostic techniques.
- Complete analysis on titanium rotor anomaly and fatigue and fracture data.
- Complete general aviation engine performance ground testing using unleaded fuels with additives and issue report.
- Conduct flight tests to correlate ground-based data with actual flight conditions for new aviation fuels.

- Complete validation of ground-based procedures for determining octane requirements.
- Initiate inflight and ground evaluations of high octane unleaded aviation gasoline formulas provided by industry.
- Complete testing on four of eight test engines for fleet octane requirement determination.

#### **Planned Activities:**

##### Engine Reliability

Advanced nondestructive engine rotor inspection research will feature the completion of improved ultrasonic methods for inspecting raw material and components during production in 1997, with industry validation in 1998. A prototype engine diagnostic and monitoring system with expert technology will be demonstrated in 1998, followed in 1999 with integrated flight tests. Current efforts to develop performance data on engine inspection techniques will be completed in 1998. An advanced fiber optic sensor capability will be demonstrated in 1999.

##### Engine Structural Safety

The research that will lead to enhanced rotor material design and durability will be completed, and a crack initiation and growth model for selected alloys will be demonstrated in 1997, with an engineering model expected in 1998. A statistics-based integration rotor design code will be delivered in 1999. A training workshop for statistics-based rotor design and durability assessment software will be conducted in late 1999.

By 2000, the advanced manufacturing processes will be established to produce premium quality titanium alloys free from metallurgical defects. The advanced titanium manufacturing process demonstration and qualification will be completed in 2002.

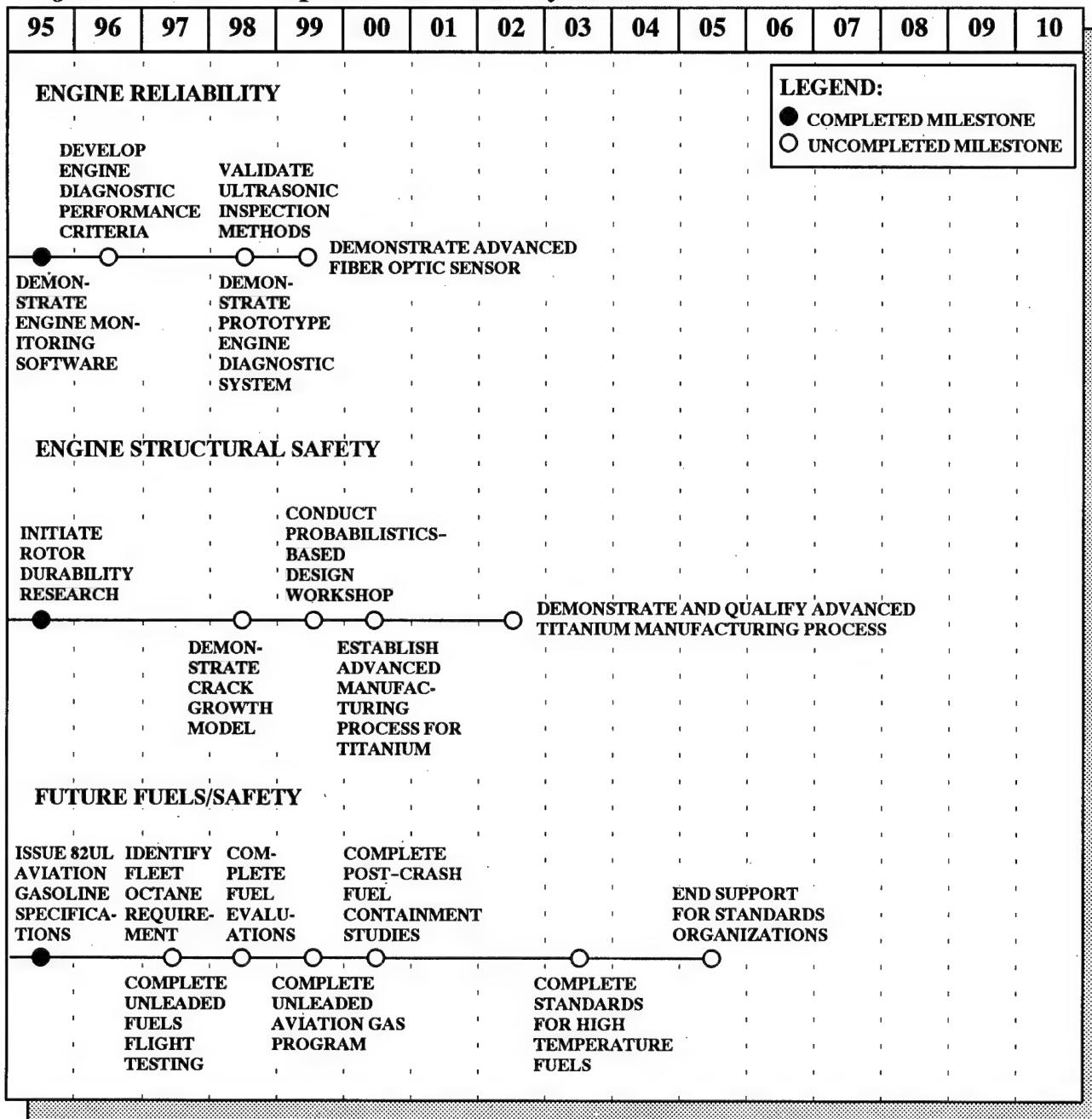
##### Future Fuels/Safety

The unleaded aviation gasoline program was restructured in 1995 due to sponsor and industry requests for specific tests and support. The changes included the establishment of a Coordinating Research Council to manage the overall unleaded aviation gasoline development program, and a two-year effort to measure the existing fleet octane requirement. The testing to determine the fleet octane requirement will continue through 1997. The industry has requested that the FAA act as an impartial evaluator of candidate fuel blends that include proprietary compounds. Proprietary fuel blend testing will continue through 1998. Individual fuel formulas provided by industry will be evaluated in either test cells or in the FAA's test aircraft. Testing to support certification efforts will continue through 1999. The revised schedule calls for draft standards for the high octane unleaded aviation gasoline to be issued to the American Society for Testing and Materials in 1998 and certification testing to begin in 1999. Specification development and certification will be completed in 1999.

A new research initiative will begin in 1998 to investigate the effects of high temperature on fuel stability, aircraft safety, and engine performance. Research on this effort will conclude with certification data and recommendations for standards in 2003, followed by support to standards organizations through 2005.

From 1998-2000 research will investigate approaches designed to improve post-crash fuel containment. These approaches will lead to potential improved fuel containment by structural modification and possible use of bladders in the inboard section of the aircraft wing tanks. The cost effectiveness of weight penalty, range penalty, and increased safety will be analyzed.

## Project 063-110: Propulsion and Fuel Systems



## 064-110 Flight Safety/Atmospheric Hazards

**P**urpose: This research has the potential to identify safety problem areas before accidents occur. This project will address new digital

technology as well as design and operational issues associated with atmospheric hazards, both natural and manmade, to provide technical data,

guidelines, advisory material, and procedures for the regulatory and certification process.

**Approach:** This project comprises three areas: aircraft icing, electromagnetic environments, and digital systems validation.

### Aircraft Icing

This project addresses both in-flight icing and ground deicing issues. Efforts will focus on assessing commuter-class aircraft with potential susceptibility to icing-induced tailplane stalls (ICTS). Flight test procedures that facilitate assessing new aircraft susceptibility to ICTS will be developed, leading to certification testing guidelines. Additional efforts will encompass research associated with large, super-cooled droplets and their effects on commuter-class aircraft.

Surface ice detector(s) and related technologies will be assessed, leading to prototype systems for evaluation. In cooperation with NASA and the Department of Defense, analytical techniques and simulation methodologies will be developed for designing and testing ice protection systems. Technologies associated with current and advanced ground anti/deicing fluids will be investigated to determine optimal application procedures, holdover-time guidelines, and associated aerodynamic effects. Analysis of the worldwide aircraft atmospheric icing environment data will continue and will include snow, ice crystals, and mixed conditions along with the super-cooled cloud analysis and freezing precipitation completed earlier.

### Electromagnetic Environment

This project will continue the research efforts to define the adverse effects on advanced technology airframes and systems caused by lightning and high intensity radiated fields (HIRF). Data currently residing in FAA data bases will support the electromagnetic analysis for HIRF and light-

ning and will also be available for dissemination at international symposiums. A cooperative electromagnetic research and development effort was conducted with the United Kingdom, and based on that effort, new protection standards for radomes and fairings will be developed. Lighting strike incident data gathered from participating commercial airlines will be analyzed to determine the adverse interaction effects to highly sensitive electronics in aircraft when composite material is incorporated into the structure. Efforts will be initiated to develop standards which address the portable electronic devices carried onboard aircraft. This project will determine a more reliable and cost-effective technique for certifying flight-critical systems. Analysis and testing will be conducted in an effort to correlate modeling techniques with full scale testing results.

### Digital Systems Validation

The digital systems validation research will address airworthiness standards and techniques as they relate to emerging, highly complex, software-based digital flight controls and avionic systems. Technical data and information relative to this new technology will help FAA certification/airworthiness specialists keep abreast of the latest avionics software and hardware developments and their potential applications in aircraft. Primary emphasis will be on flight safety issues pertaining to the application of this technology to flight critical systems. This project will evaluate current system safety assessment methods and modify or develop new techniques as required. An assessment of the electromagnetic effects associated with fly-by-light (FBL)/power-by-wire will also be addressed. This work will be accomplished in coordination with NASA.

**Related Projects:** 022-140 General Aviation and Vertical Flight Program, 041-110 Aviation Weather Analysis and Forecasting, 065-110 Aging Aircraft, 067-110 Fire Research, and 075-110 Aircraft Hardening. Capital Investment

Plan projects: F-16 Technical Center Building and Plant Support and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- Pilot's Guide to Aircraft Ground Deicing advisory circular (AC)
- Report on field measurements for advanced anti/deicing fluid time of effectiveness
- Report on validating analytical technologies, computer codes, and simulation methodologies
- Electromagnetic Handbook
- Advisory material addressing portable electronic devices data base
- Electromagnetic threat definition, development, and validation
- Lightning AC and user manual updates
- HIRF AC and user manual updates
- Tutorials/chapters for the Digital Systems Validation Handbook
- Technical report on flight critical digital systems technology studies for assessment and development of airworthiness and certification methods
- Software development guidelines report and data package
- Data to support operational procedures development for advanced rotorcraft/tiltrotor instrument flight rules approaches to heliports
- Aircraft surface ice detection technologies and systems

#### **1996 Projected Accomplishments:**

- Evaluate time of effectiveness for recently developed anti/deicing fluids under various freezing precipitation conditions.
- Evaluate polarized radiation-based aircraft surface ice detector technology.
- Complete flight testing on ICTS susceptibility.
- Complete full authority digital engine controller testing in a production helicopter.
- Issue notice of proposed rulemaking to address new lightning protection fuel tank standards.
- Expand the FAA research and development electromagnetic data base.
- Publish three chapters of the HIRF handbook.
- Publish Digital Systems Validation Handbook – Volume III, Chapters 1 and 2.
- Publish technical report on software performance service history for certification specialists.
- Complete FBL fiber optics technology assessment for FBL/power-by-wire digital flight control and avionics systems concepts.

#### **Planned Activities:**

##### Aircraft Icing

In 1997, analytical tools and simulation models that will assess aircraft design susceptibility to ICTS will be developed. Also in 1997, a report will be published on ICTS susceptibility. Efforts will continue to define and characterize the large super-cooled droplet environment and to assess their effects on selected airfoils and aircraft designs. Analysis and development work on

aircraft mounted surface ice detection technologies will continue through 2001. The technologies investigated will include an integrated strip and spot sensor 1997-1998, near-infrared area coverage sensors 1997-1999, and integrated ultrasonic capacitive-based sensors 1997-1999. In 1999, a decision will be made on which technology to develop into a surface ice detection area coverage system for implementation in 2001.

In 1997, new and advanced deicing fluids will continue to be evaluated for their time of effectiveness and their aerodynamic performance. These evaluations will lead to updated holdover-time guidelines in 1998.

In 1997, anti-icing research in this project will culminate in a technical report on ice phobic technologies such as ice shedding materials and coatings, and low energy anti-icing techniques. An important product in 1997 will be a technical report on icing-induced tailplane stalls and the interrelation of variables that cause or contribute to these stalls. Design material to preclude this phenomenon will be provided. In 1997, in conjunction with NASA, analytical codes will be developed for use on rotorcraft and small airplanes. Ice detection systems are planned for 1998. In 1999, both aircraft-mounted and handheld surface ice detectors with localized coverage will be developed. Further research will lead to publishing advisory material to facilitate icing certification of small airplanes and rotorcraft in 2000, and developing universal coverage surface ice detectors in 2001.

Additionally, newer aircraft such as tiltrotor-powered-lift, supersonic transport, and the national aerospace plane will require innovative ice protection technologies and attendant innovative approaches for certification.

### Electromagnetic Environment

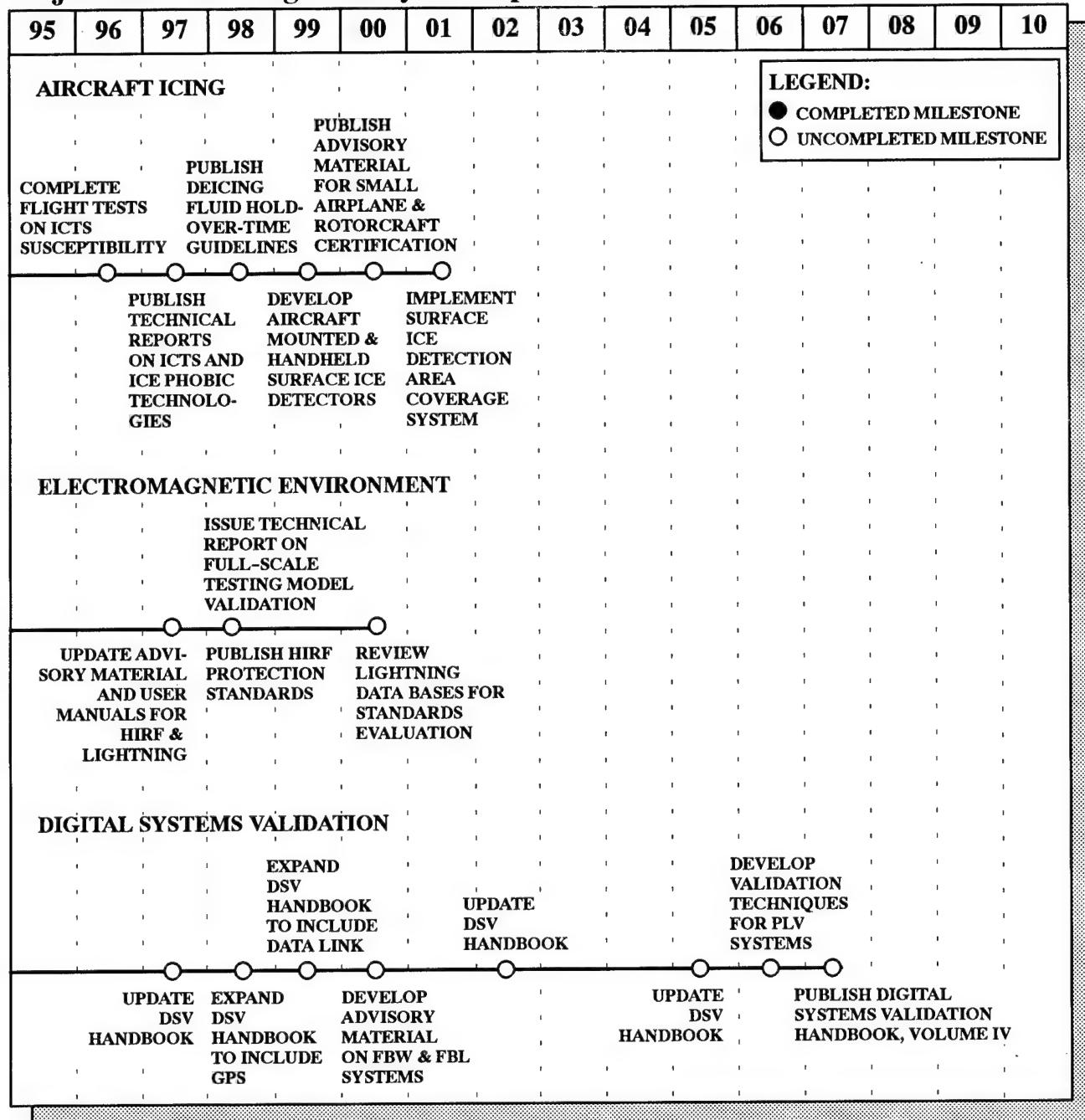
In 1997, advisory material and users manuals will be updated to support aircraft certification requirements on HIRF and lightning protection. The data sources will be analyzed in 1997 and, if appropriate, incorporated into the rulemaking process. Research from this project will be presented to the international electromagnetic community at symposiums in Washington, D.C. and Colorado. In 1998, a HIRF systems technical report on full-scale testing model validation will be issued, and HIRF flight control/avionics protection standards will be published.

In 1997, research will be initiated to determine a means of in-situ identification of potential hazards caused by portable electronics devices. A report will be published in 1998 and new standards developed in 1999. In 2000, an effort will be initiated to review lightning data bases to determine if the current standards used for the direct and indirect effects during certification are appropriate.

### Digital Systems Validation

In 1997, research will continue to address airworthiness and certification issues relative to constantly emerging technology. The Digital Systems Validation (DSV) Handbook will continue to be updated to assist FAA engineers with the new technology to ensure flight safety. In 1998, the handbook will be expanded to include a chapter on the global positioning system (GPS). In 1999, a chapter on data link will be added. Technical data and information on fly-by-wire (FBW) and fly-by-light systems will be compiled for development of advisory materials for FBL flight controls and avionic systems in 2000. In 2006, validation techniques will be developed for powered-lift vehicles. In 2007, the Digital Systems Validation Handbook - Volume IV will be published.

## Project 064-110: Flight Safety/Atmospheric Hazards



## 065-110 Aging Aircraft

**Purpose:** Aging airframe structures have shown increasing susceptibility to widespread fatigue damage and corrosion that could

pose a threat to their structural integrity. Instances of structural failures point to the need for increased reliability in inspection methods.

Furthermore, the demands on the aviation safety inspectors due to the aging aircraft fleet require automated data tracking improvements. This research effort will develop the means for evaluating and ensuring safety and reducing the risks associated with aging aircraft structures. The three thrust areas of this project are: structural design, maintenance and inspection, and automated methods for surveillance of information relating to the aging aircraft fleet.

The various research activities will also include technology transfer of technical material and knowledge to industry and foreign regulatory agencies.

#### **Approach:**

##### Structural Integrity

To address aging aircraft structural design problems, improved methodologies and test data are needed. Models and data will be developed to correlate service experiences with test and analysis results. Design alternatives that delay or eliminate widespread fatigue damage will be identified.

To provide passengers with the most consistent level of safety practical, whether service is provided by transport or commuter category airplanes, a methodology for developing supplemental inspection documents will be established for commuter airplanes in scheduled service.

The corrosion effects on fatigue and fracture will be quantified and evaluated. Analytical fracture models resulting from this work will be used as a basis for rulemaking.

Means for evaluating the effect of single and multiple repairs on airframe structural integrity will be developed. This work will benefit independent repair stations and smaller air carriers.

Modern flight and ground load data collection systems have been developed and installed on

both small and large transports. Flight usage profiles and structural loading histories will be determined for the current fleet. Technical data to assess the continued applicability of load-related regulations will be generated.

##### Maintenance and Inspection

Improvements in maintenance practices and training, as related to repair and corrosion control, will be developed and offered to heighten awareness of structural degradation modes among the aviation community, particularly the aviation maintenance technicians and inspectors. Increased emphasis will be placed on maintenance human factors and human performance. A job task analysis will be conducted to identify critical maintenance and inspection tasks and establish a basis for training updates. An analysis of current communication processes will be conducted to identify difficulties and to establish guidelines to improve technical documents to ensure that the information is interpreted as intended.

Existing and emerging nondestructive inspection equipment and methods will be evaluated for their capability to detect material defects. Prospective technologies are being developed that offer improvements in detectability, reliability, ruggedness, automation, human performance, and cost. Prototype systems will be developed and tested. The most promising technologies will lead to cooperative research and development agreements with industry for technology transfer. Additionally, advisory material will be developed for inspection facilities, equipment, and personnel.

##### Information Systems

In this area, safety analysis and information management systems will be developed. These systems will be designed to audit critical performance indicators, identify safety risks, and maintain information for certificate holders approved by the FAA. Specifically, these

systems will have the capability to interrogate data relating to air operators, aircraft, air agencies such as repair stations and training schools, and air personnel.

**Related Projects:** 062-110 Advanced Materials/Structural Safety, 063-110 Propulsion and Fuel Systems, 064-110 Flight Safety/Atmospheric Hazards, 075-110 Aircraft Hardening, and 085-110 Aircraft Maintenance Human Factors. Capital Investment Plan projects: A-15 Civil Aviation Registry Modernization, A-17 Aviation Safety Analysis System (ASAS), A-18 Safety Performance Analysis System (SPAS), A-20 Integrated Flight Quality Assurance, F-16 Technical Center Building and Plant Support, M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance, M-18 Computer Resources Nucleus (CORN), and M-24 National Aviation Safety Data Analysis Center (NASDAC).

#### **Products:**

- Damage tolerance training materials for FAA certification personnel
- A maintenance and inspection management program for commercial pressurized engine cases that will be used to derive regulatory documents
- Analytical tools and models to assess commuter and transport aircraft structural integrity and repairs
- Technical data used to formulate the Special Federal Airworthiness Regulation and advisory circulars on widespread fatigue damage and the corrosion fatigue interaction
- Technical data for flight and ground loads encountered by transport and commuter airplanes that can be used for design, certification, and airframe life assessment

- Training tools, aids, and material for repair, maintenance, and inspection personnel
- Data base on airframe maintenance, inspection, repair and corrosion control procedures, and aircraft engine testing
- Inspection systems for flaw detection in airframe structures and engines for compliance certification
- Supplemental inspection documents for commuter category airplanes to provide for the continuing airworthiness of the commuter fleet
- Safety performance analysis system (SPAS) that contains safety-critical performance indicators on air operators and air agencies

#### **1996 Projected Accomplishments:**

- Develop an analytical tool for designing and analyzing airplane fuselage skin repairs.
- Complete reliability assessment of various visual inspection tasks.
- Complete report on development and beta-site testing of emerging nondestructive inspection devices, including thermal inspection techniques, pulsed eddy current methods, enhanced visual systems, and signal processing algorithms.
- Publish technical report on flight load usage data for large transport aircraft.
- Conduct video landing parameter surveys at one major commercial airport.
- Install 11 optical disk recorders on B-737 and Md-80 aircraft.

- Develop user-friendly computer tool for determining FAR 23 design and fatigue loads from basic geometry information.
- Complete the technical interface between flight loads research and the Flight Operational Quality Assurance program.
- Develop an analytical model on fretting fatigue.
- Provide data for an advisory circular on the development of a corrosion control program for commuter aircraft.
- Develop weighted job task definitions for aviation maintenance technicians.
- Develop guidelines for improving the communication of technical information.
- Develop a strategic plan for aviation maintenance human performance to integrate and coordinate human factors and human performance across flight standards, aviation medicine, and aviation research.
- Develop parameters for aircraft turbine engine component inspection systems.
- Release SPAS I, Version 2 including air operators, air agencies, and aircraft indicators.
- Develop requirements, test, and evaluation plan for risk analysis decision support (RADS) capabilities.
- Release international aircraft operator information system.

#### **Planned Activities:**

##### **Structural Integrity**

In 1997, testing of full-scale aircraft panels will continue to determine multi-site damage effects on residual strength, and residual strength predic-

tive methodologies will be validated. Also, in 1997, methodologies will be developed that predict widespread fatigue damage. These methodologies will be integrated into an overall risk assessment methodology in 1998. In 1999, the analytical methodologies will be extended to structural modifications and corrective actions.

Factors affecting fatigue and airframe design fracture resistance will be studied, leading to design guidelines in 1999. In 2000, research will be completed on a tool that designs and analyzes repairs to complex metal aircraft structures.

From 1997-2000, development work will be conducted on a global risk analysis model that predicts residual strength of aircraft structures subjected to widespread fatigue damage. A prototype will be developed in 1998 for testing and evaluation through 2000. Residual strength research will be completed in 2003 when the various structural models are validated and made available for industry use.

From 1997 through 2010, supplemental inspection documents will be developed for additional airplane models in the commuter fleet. In 1997, development will continue on a data base for aircraft engine materials to formulate crack growth-based methodologies. The methodologies will be developed by 2000 to derive inspection and maintenance requirements for engine pressurized static cases. These methodologies will be tested and validated in 2002 at which time engine life prediction research will be completed.

From 1997-2003, flight and ground loads data collection will continue for structural analysis programs. An additional 12 optical disk recorders will be installed on B-757, B-767, and A-320 aircraft. Six solid state recorders will be installed on both Beechcraft 1900D and Fairchild Metro III airplanes. Three video landing parameter surveys will have been completed by 1997 with a fourth survey planned in 1998. A computer methodology will be developed in 1997 to determine structural design and fatigue loads from

basic airframe data on small airplanes. This methodology will be extended to commuter aircraft, validated in 2000, and refined for industry use in 2001.

#### Maintenance and Inspection

A prototype PC-based repair tool addressing aircraft structural modifications will be evaluated from 1997-1998 for field implementation in 1999. In 1997, corrosion control products will be evaluated. Specifications will be developed for composite-to-metal repairs in 1997, with repairs analysis planned for completion in 1999.

In 1998, repair station housing and equipment criteria will be developed for airframe and engine structural repairs. Additionally, a data package leading to an advisory circular on engine test cell data correlation will be completed to eliminate anomalies between individual repair stations.

Updated weighted job task definitions will be used to develop aviation specialist qualifications and standards in 1998.

Research on validating and assessing inspection techniques will continue through 2004 at the Aging Aircraft Nondestructive Inspection Validation Center. In 1997 a subset of emerging flaw detection devices will be selected for further development and validation. Emphasis will be placed on small crack detection and detection of subsurface and second or third layer flaws. Validation of the devices will continue through 2000. As evaluations are completed on these prototypes, field systems will be implemented for industry use by 2005.

In the engine inspection area, a prototype eddy current array probe and a portable eddy current scanner for in-service engine component inspection will be completed in 1997. Ultrasonic meth-

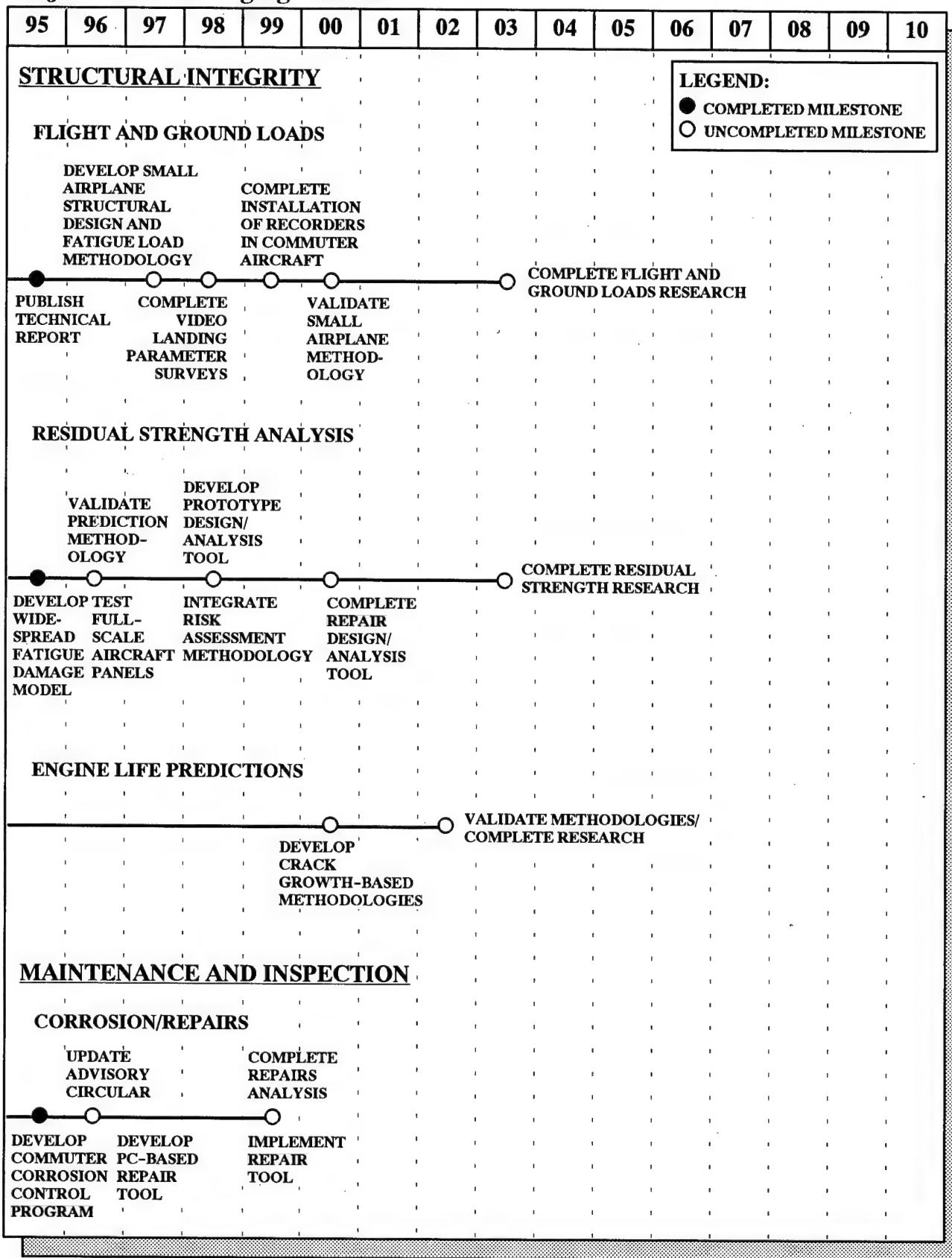
ods for inspecting engine material and components during production will be developed in 1998 and validated in 1999. Also in 1999, research will begin on developing fluorescent penetration inspection improvements that will detect smaller flaws with greater reliability. These techniques will be evaluated through 2005 to test their reliability. The fluorescent penetration inspection improvements will be approved for industry use by 2007.

#### Information Systems

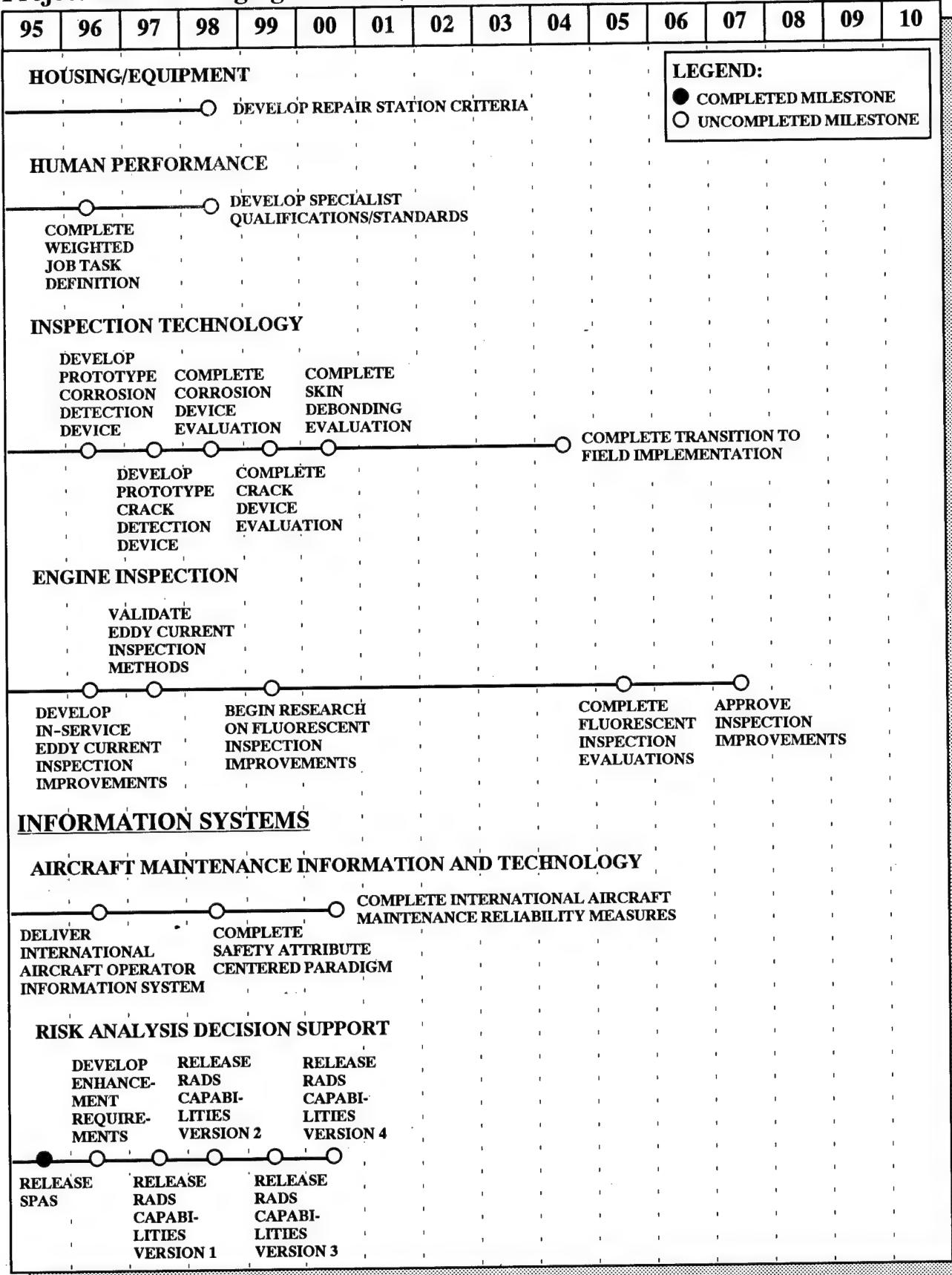
In 1997, development work on risk assessment and information display capabilities will continue. Critical performance measures to support both flight standards and air certification personnel will be developed, tested, and implemented into existing analytical systems such as SPAS. In addition, flight standards and air certification information and decision support systems will be continually enhanced with artificial intelligence, expert system, and advanced graphics capabilities. The first set of these capabilities is scheduled for release in 1997, with enhanced capabilities scheduled for release in 1998, 1999, and 2000.

In 1997, research efforts will continue on improving the capability to collect, standardize, analyze, and disseminate aircraft maintenance and mechanical reliability data. Special emphasis will be placed on mechanical reliability reports. In addition, a major effort will begin on performing a data-driven optimization of the aviation safety monitoring processes that are conducted by aviation safety inspectors and industry auditors. A product from this effort will be the safety attribute-centered paradigm in 1998. A follow-on product will be a set of aircraft maintenance reliability measures that can be used by the international aviation community by 2000.

## Project 065-110: Aging Aircraft



# Project 065-110: Aging Aircraft (continued)



## 066-110 Aircraft Catastrophic Failure Prevention Research

**Purpose:** This project will establish and direct a research effort to identify, reduce, and prevent aircraft system problems that could result in catastrophic aircraft failures. This failure prevention research will reduce catastrophic accident risks and the number of hull losses, injuries, and fatalities. Information developed from this project will be disseminated to the aircraft industry on a regular basis. This research is required by Title IX of the Omnibus Budget Reconciliation Act of 1990 (Public Law 101-508), "Aircraft Catastrophic Failure Prevention Research Program."

**Approach:** This project will conduct research to develop methodologies that characterize and assess the risks associated with potentially catastrophic aircraft hardware, software, and operational problems. Further research will evaluate, test, and develop technologies to prevent and minimize these hazards. Technology transfer will utilize the technical bases of industry, academia, non-profit laboratories, and other government agencies. The research will address failure scenarios that involve the interaction of several aircraft systems as well as more specific failure types such as turbine engine/auxiliary power unit, fuselage structural, and damaged or failed flight control systems.

### Certification/Regulation Investigations

A study of accidents and incidents and their relationships to current regulations will be performed. This study will define areas within the federal aviation regulations and advisory materials that need revision. The various methods used to demonstrate compliance with regulations will also be analyzed. The appropriate use of reliability analysis, comparison with similar systems, simulation and flight testing within a certification program will be defined in the form of guidelines for certification engineers.

### Turbine Engine Failures

A failure in turbine engine and auxiliary power unit rotating components can be a serious safety hazard to critical aircraft systems because high energy fragments can be released. The traditional approach to minimize these hazards is to isolate individual engines and auxiliary power units from other engines and flight critical systems. More effective containment or protective shields are an underutilized approach due to weight and complexity penalties. This project will determine high energy fragment characterization and evaluate protective shield material technology. A comprehensive advanced lightweight material technology review will be conducted, and new material concepts will be developed for absorbing high kinetic energy fragments in the largest turbofan engines. Further efforts will provide a methodology to determine catastrophic failure probability and risk assessment. This methodology will be used to develop an analytical model of uncontained fragments from gas turbine engine and auxiliary power unit rotating component failures. This model will assist in assessing the catastrophic failure risk in current and future designs by identifying critical systems and structures needing protection.

### Structural Failures

Research will be directed toward advanced means to predict and prevent catastrophic structural failures on future commercial transport aircraft. Research will also be directed toward advanced means to predict, with known probability, aircraft structural loads during the aircraft design phase. Studies will define the flight and ground conditions under which horizontal stabilizer structural loads can occur. Experts will investigate the use of statistical studies for predicting maximum design gust loads on aircraft. Proposed airworthiness requirements which

define the gust limit load will be evaluated and implemented, if required.

### Flight Control Failures

This project will address specialized technology fields that concentrate on preventing catastrophic flight control failure after an in-flight accident or incident. Research will assess what failed-mode flight control options are practical for any control failure case to ensure continued safe flight and landing. This project will concentrate on studies that include areas such as: substitute, alternate, and reconfigurable control systems; flying qualities criteria; stability and control; situational awareness; and human factors. A program of modeling analysis simulation and variable stability aircraft flight tests is planned to provide technology that could be beneficial in failed-mode flight control situations. The proposed approach will test both aerodynamic aspects and aircraft stability and control. This approach will: develop technology to improve aircrew emergency procedures; provide aircrew training that simulates damaged aircraft handling qualities; conduct research on damaged flight control airworthiness issues; provide a real-time flight control cockpit advisory system; design and test innovative failure tolerant flight control systems; and establish metrics to quantify and compare the robustness and failure tolerance of flight control systems.

**Related Projects:** 022-140 General Aviation and Vertical Flight Program, 062-110 Advanced Materials/Structural Safety, 063-110 Propulsion and Fuel Systems, 067-110 Fire Research, and 075-110 Aircraft Hardening. Capital Investment Plan projects: F-16 Technical Center Building and Plant Support and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

### **Products:**

- Prioritized list of regulations and advisory materials requiring review or revision
- Advanced materials suitable for airframe barriers
- Guidelines establishing appropriate regulation compliance methods
- Model of uncontained debris from turbine engine rotating component failures
- Aircrew emergency procedures and new systems for damaged or failed flight control systems
- Failure modes risk assessment analysis methodology tools
- Predictive techniques and analysis of gust loading conditions and airworthiness requirements for maximum gust loads
- Failed-mode flying qualities assessment system and situational awareness/cockpit resource management procedures

### **1996 Projected Accomplishments:**

- Complete small turbine engine containment tests.
- Complete analytical study of uncontained turbine rotor fragment penetration threat to aircraft wing fuel tanks.
- Determine applicable advanced turbine rotor fragment barrier materials.
- Complete uncontained turbine rotor fragment characterization.
- Complete technology review of advanced armor concepts for turbine debris mitigation.

## Planned Activities:

### Certification/Regulation Investigations

In 1997, an intensive investigation of regulations, advisory materials, and certification techniques will begin based on the results of the aircraft accident, incident, and regulation study. Areas in need of revision will be studied thoroughly, and modifications will be proposed from 1997 through 2001. A quantitative risk assessment and probability of failure methodology will be demonstrated on representative transport category aircraft systems beginning in 2001.

### Turbine Engine Failures

In 1999, a prototype computational model will be developed to simulate rotor fragment dispersal, barrier penetration, and aircraft damage. Model validation will take place through 2000, with final development expected by 2001. An

advanced barrier materials report will be published in 1997.

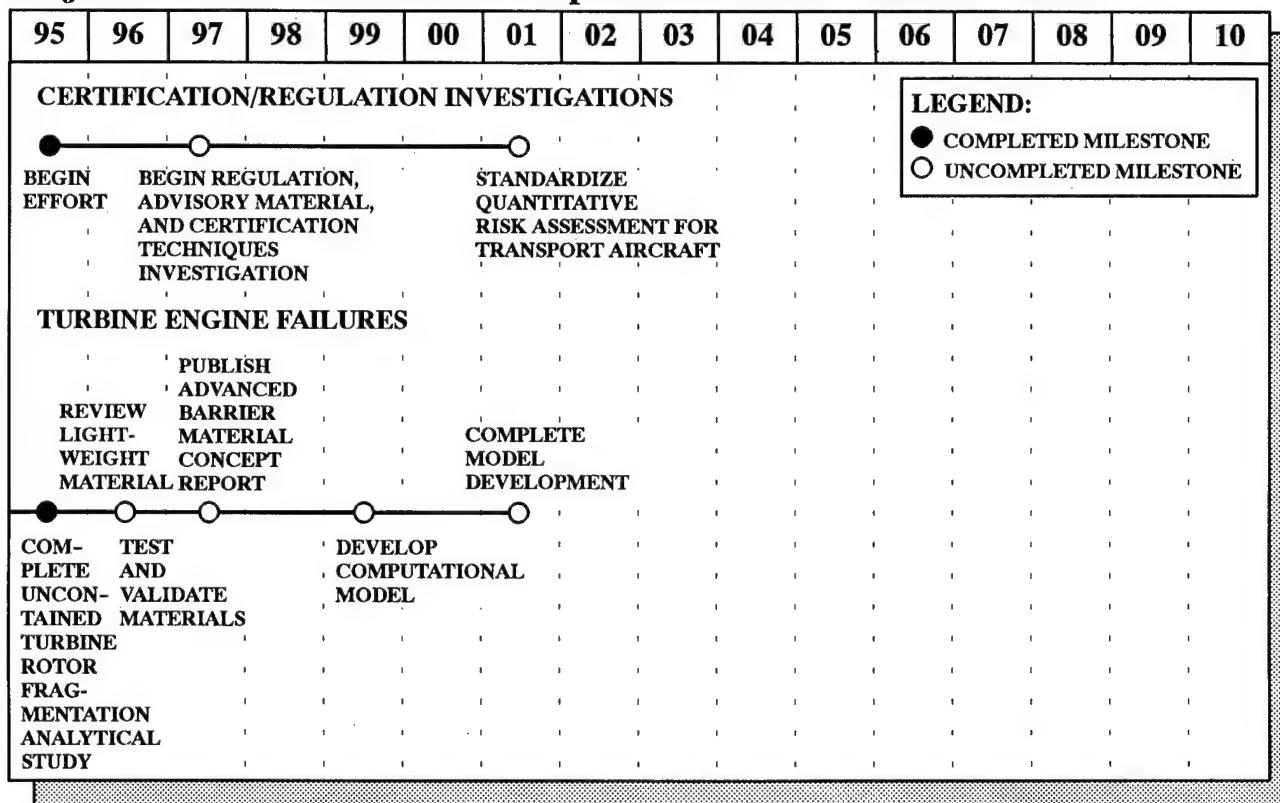
### Structural Failures

Contemporary and future airframe anti-symmetric buffet load analysis and testing will continue through 1998.

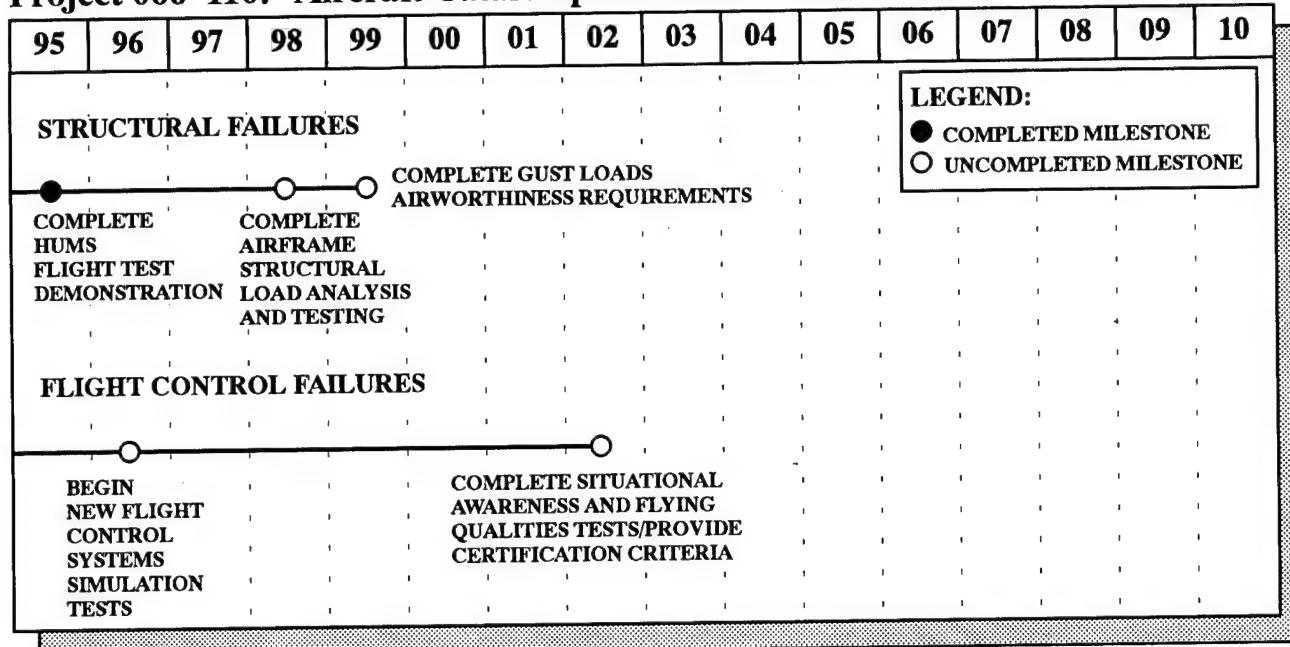
### Flight Control Failures

In 1997, continued research will assess the viability of failed-mode flight control options for emergency operational conditions. Situational awareness and flying qualities assessment issues relative to failed-mode flight control and advanced cockpit automation will be addressed during 1997-2002. This effort will provide agency flight test pilots with type- and operational-certification criteria for failed-mode flight in 2002.

## Project 066-110: Aircraft Catastrophic Failure Prevention Research



## Project 066-110: Aircraft Catastrophic Failure Prevention Research (continued)



## 067-110 Fire Research

**P**urpose: The Aviation Safety Research Act of 1988 requires the FAA to conduct long-term fire safety research to eliminate fire as a cause of fatalities in aircraft accidents. This project will investigate new technologies to improve fire safety for current and future aircraft. Research will develop fire-safe cabin materials, smart systems for aircraft fire hazard control, new techniques for fire suppression, and low flammability safety fuels.

**Approach:** This project will focus on six interrelated research areas: fire modeling, vulnerability analysis, fire-resistant materials, improved systems, advanced suppression, and fuel safety. Research in all these areas must be accomplished to satisfy the overall goal of making a fire-resistant cabin.

### Fire Modeling

This project will develop computer models to predict the initiation and growth of in-flight and post-crash fires. These models will have the flexibility to create virtually the entire range of accident scenarios and will identify critical performance requirements for aircraft materials and systems. The models will undergo a validation process that compares the model results against full-scale test results and updates the modeling techniques as needed.

The modeling effort will provide the basic tools for an aircraft fire risk and vulnerability analysis with a resulting technology that can be used to predict the safety of a given aircraft design. This technology has direct application to both in-flight and post-crash fire threats. Employing the aircraft fire analysis tools will identify weak links that increase vulnerability to fire. These weak links will show where improvements are needed

in existing materials, structures, or systems. Identifying shortcomings in cabin material flammability properties could lead to a specification that would make the aircraft interior totally fire resistant in accidents. Other weak links might be in design deficiencies that can be cured by applying new fire protection systems. The analytic tools can also provide the capability to determine when fire safety improvements reach the point of diminishing returns.

### Vulnerability Analysis

In-flight fire vulnerability research can show what systems are most likely to cause a fire, what systems are likely to fail in a fire, and what fire scenarios are most likely to have catastrophic results. The conditional probability of a catastrophe then provides a basis for estimating fire safety of a given aircraft design. The relative magnitudes of the individual probabilities can be used to identify the design features, systems, and materials where improvements will be most beneficial.

Probabilistic statistical techniques will be used to identify the likelihood of different post-crash fuselage breakup configurations with varying terrain and weather conditions. These scenarios will be used to establish performance requirements of mathematical fire models.

### Fire-Resistant Materials

This project seeks to eliminate cabin fire as a cause of fatalities in aircraft accidents by developing polymer and composite cabin materials with significantly reduced ignitability, smoke, and heat release compared to current FAA requirements. Novel synthetic chemistry, process research, and fundamental studies of materials flammability will lead to non-combustible cabin components which are lightweight, serviceable, and environmentally sound. The goal is a totally fire-resistant cabin for next-generation aircraft.

Advanced material research will require determining the fundamental relationships between material composition and behavior in aircraft fires. To determine these fundamental relationships, the project will employ molecular modeling to predict fire test performance of new fire-resistant materials. This modeling will provide the basis for synthesizing new materials and developing new combustion and structural response models that can be used in aircraft materials design.

Novel materials emerging from this long-range program will improve ground transportation fire safety and find application in the fire/thermal protection, electronic, and biomedical industries.

### Improved Systems

Research in this area will focus on eliminating electrical and mechanical devices as fire causes, as well as assuring the continued functionality of critical systems when exposed to fire. Other research will investigate improvements such as better resources to aid the flight crew and means to minimize occupant hazards.

The project will use results from vulnerability analyses and fire modeling to identify which systems are most vulnerable from exposure to fire or smoke. Improved systems will be developed based on these analyses. Highly sensitive and gas-specific sensors, coupled to artificial neural networks, will be used to develop more reliable and timely fire warning systems. Fire modeling of in-flight fires will lead to improved techniques for cabin smoke control and removal.

### Advanced Suppression

Existing aircraft fire suppression systems are based almost exclusively on trial and error development. This project's long-term basic research will close technology gaps by providing a fire suppression science. Research will focus on disrupting high temperature chemical reactions in material combustion through models and simulations.

In parallel with the basic research, the project will evaluate new technologies such as gas membranes to provide a realistic onboard inert gas generating system (OBIGGS) as an alternative approach for fire suppression. Further research will examine material combinations that release suppression chemicals when heated. Synergistic effects will be sought which will allow developing hybrid suppression systems.

### Fuel Safety

Research in this project will focus on fuel additives that can affect fuel flow behavior, breakup characteristics, vaporization, and surface characteristics. Fuel safety improvements will be developed using a variety of chemical ingredients that change the mechanical or chemical behavior of fuel released in an aircraft crash. Studies will focus on finding additives that make fuel ignition less likely or that reduce the fuel energy release rate when ignition does occur. Modeling and experiments will be used to find the parts of the fuel burning processes where additives will have the most effective impact. Based on research results, additive formulations will be developed to optimize their effectiveness in reducing fuel fire threats.

**Related Projects:** 051-130 Airport Safety Technology, 061-110 Aircraft Systems Fire Safety, 062-110 Advanced Materials/Structural Safety, 064-110 Flight Safety/Atmospheric Hazards, 066-110 Aircraft Catastrophic Failure Prevention Research, and 069-110 Cabin Safety. Capital Investment Plan projects: F-16 Technical Center Building and Plant Support and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

### **Products:**

- Computer fire codes predicting hazards to passengers and damage to aircraft systems

- Probabilistic risk assessment methods for objectively evaluating fire risk associated with specific aircraft designs, systems, and procedures
- Totally fire-resistant materials for fabricating aircraft cabin interiors
- Aircraft design features to reduce inherent fire risks
- Fire suppression systems
- Fire and smoke detectors employing neural networks to eliminate false alarms
- Fuel additives that reduce the intensity of post-crash fuel fires
- Fuel compositions that lower spilled fuel ignition probability

### **1996 Projected Accomplishments:**

- Develop inexpensive, totally non-combustible, polysialate/carbon fiber composites for interior cabin applications.
- Synthesize new fire-resistant triazine polymers for aircraft cabin panels.
- Establish analytical methodology for bench-scale evaluation of new fire-resistant materials.

### **Planned Activities:**

#### Fire Modeling

In 1998, existing industrial fire models will be compared for accuracy in predicting in-flight fire behavior. In 1999, research will be directed at code modifications to obtain more realistic

results. In 2001, the models will be used to establish requirements for the fire resistant material research. Subsequently, in 2003, in-flight fire models will be available for vulnerability analysis, and in 2004, simplified risk assessment fire models will be available for the major types of in-flight fires.

In 2006, a fuselage burnthrough model will be coupled with the fire model previously tested for crash scenarios with wind effects. In 2009, a comprehensive model will be available for all major post-crash fire scenarios, and fire modeling research efforts will be completed in 2010.

### Vulnerability Analysis

In 1998, an analysis will be completed to identify in-flight fire ignition sources. In 1999, the likelihood of different post-crash fuselage breakup configurations will be established. In 2001, risk and vulnerability analysis techniques will be completed for in-flight fires leading to determining required fire endurance improvements in 2002. In 2003, special fire risks associated with the high-speed civil transport will be identified. In 2005, a comprehensive analysis capability will be available for all in-flight fire scenarios. Vulnerability analysis research will be completed in 2006.

### Fire-Resistant Materials

In 1997, work will continue on synthesis of new thermoset and thermoplastic polymers, leading to fire-resistant cabin lining materials in 2000 and fire-resistant electrical insulation in 2002. Research into new synthetic chemistries for inorganic elastomers will yield inexpensive, fire-safe seat cushions, pillows, adhesives, and sealants in 2005. By 2008, new materials will be processed into fire-safe textile fibers for seating upholstery, tapestry, blankets, and carpeting. In 2010, a prototype fire-safe cabin will be assembled for full-scale fire tests by the Aircraft Systems Fire Safety project at the FAA Technical Center.

### Improved Systems

In 1998, research will begin on smart fire detection and cabin smoke control systems, with completion expected in 2002. In 2003, the fire endurance of all onboard critical systems will be identified. In 2005, hardening techniques for critical systems will be established, and in 2008, technology for fire-safe electrical systems will be established.

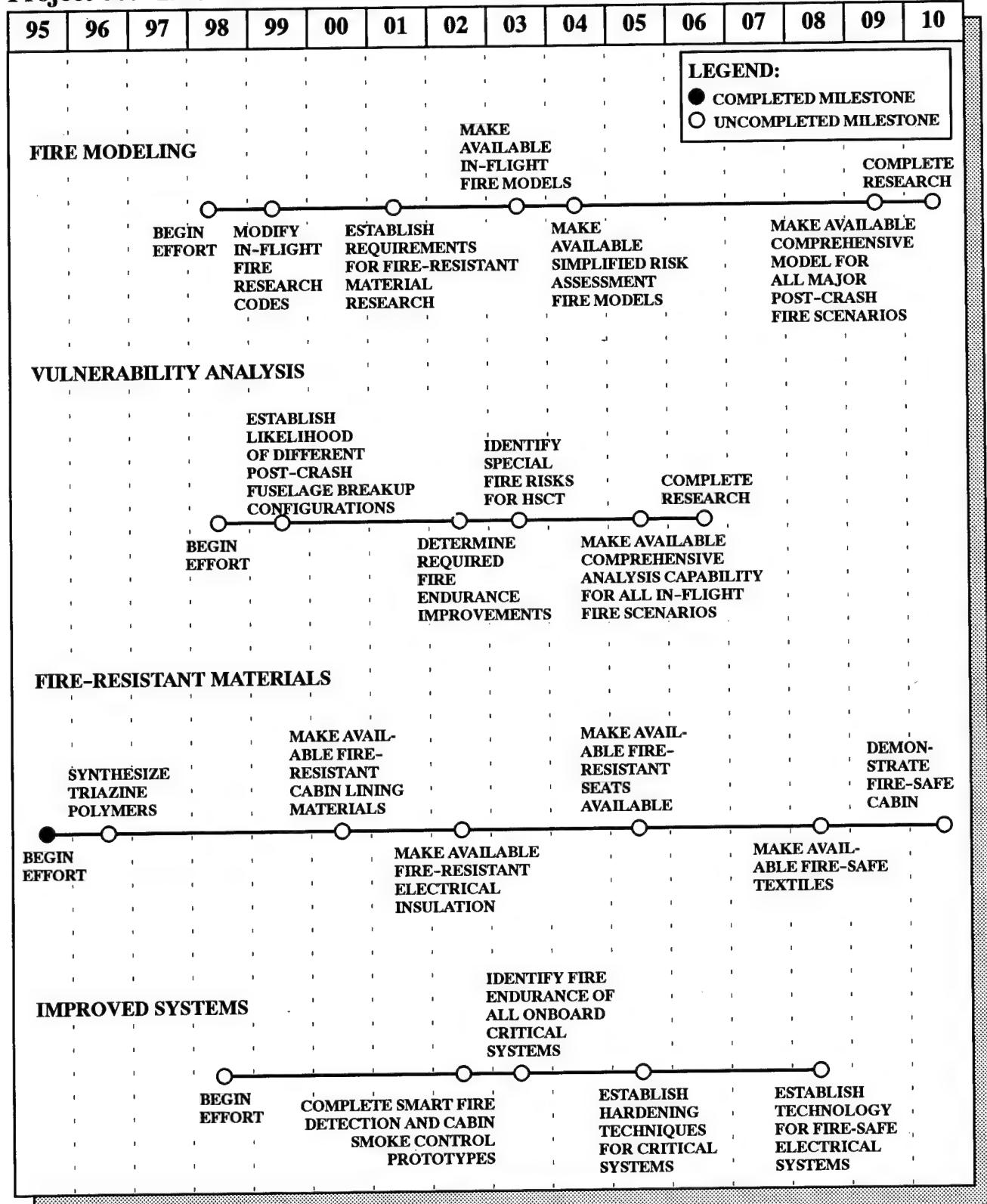
### Advanced Suppression

In 1998, a feasibility assessment will be completed for an OBIGGS system with subsequent prototype completion in 2001. In 1998, work will also begin on a prototype hybrid extinguishing system. Attractive synergistic combinations will be selected in 2002, with a prototype hybrid system completed in 2004. Basic research on suppression chemistry will be initiated in 1998, and hybrid reaction characterization will begin in 2000. From these efforts, an extinguishing system computer model will be completed in 2005. In 2008, the capability will be completed for optimizing new aircraft extinguishing techniques. Research in advanced suppression will be completed in 2009.

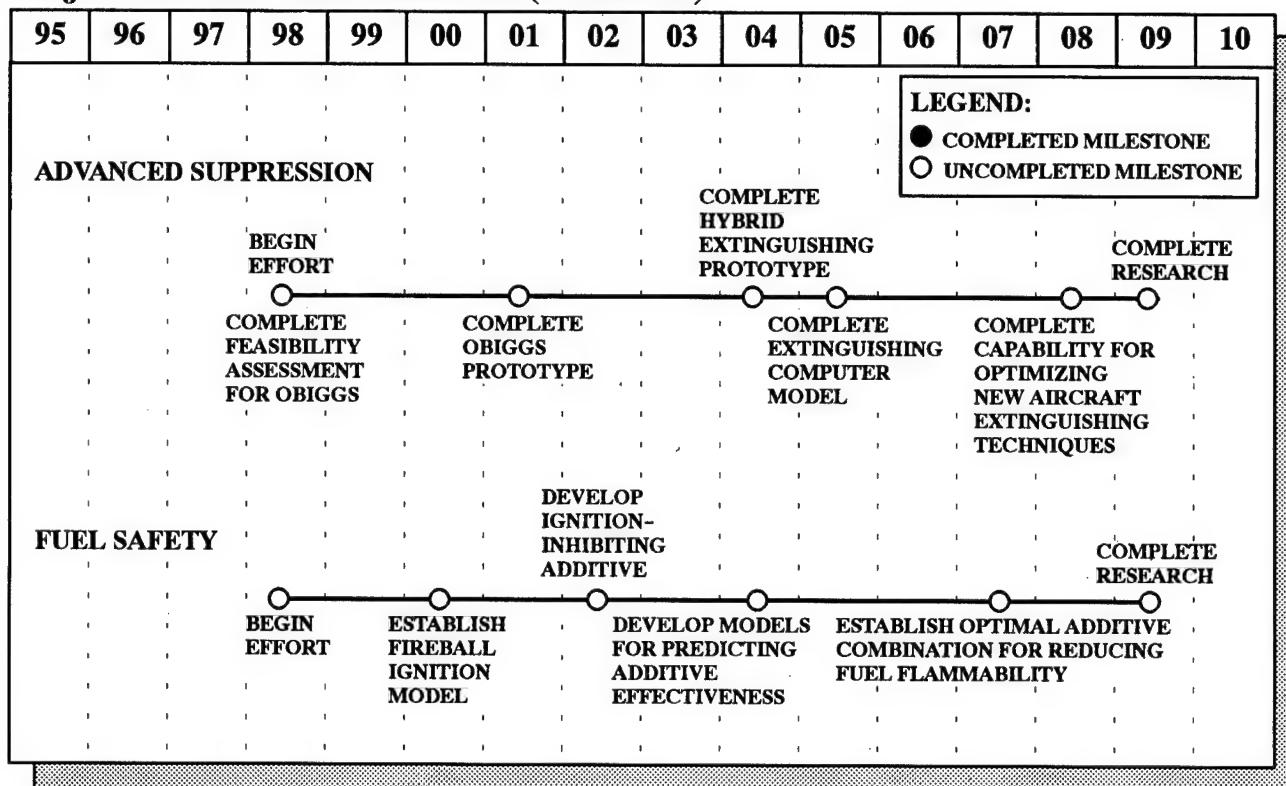
### Fuel Safety

In 1998, experimental and theoretical work will be initiated on flames propagation caused by sprays of additive-containing fuel. This work will lead to establishing a fireball ignition model in 2000 that will be used to develop an ignition-inhibiting additive by 2002. Work initiated in 2000 on additive-containing fuel burning rates will result in models in 2004 to predict how additives affect the heat release rate of large, wind-blown fuel fires. Following full-scale model verification tests during 2005-2006, an optimal additives combination will be established in 2007 for reducing fuel flammability. Research in this area will be completed in 2009.

# Project 067-110: Fire Research



## Project 067-110: Fire Research (continued)



## 069-110 Cabin Safety

**P**urpose: Cabin safety involves acute safety problems that occur within, or can be corrected by, changes within the cabin. For many years, the FAA, the European Joint Airworthiness Authority (JAA), and Transport Canada (TCA) have been conducting research in cabin safety, mostly individually, and sometimes jointly, without the benefit of a coordinating tool. The international nature of civil aviation, current trends in harmonization, and budgetary constraints dictate the need for a mechanism to foster a collaborative effort in cabin safety research. This effort will coordinate the diverse cabin safety research activities related to evacuation, crash dynamics, fire, and in-flight medical emergencies on an international level.

**Approach:** This project will assemble an international working group composed of regula-

tory authorities and research personnel. Comprehensive risk/benefit analysis models and data bases on past accidents and incidents involving cabin safety will be developed. Computer models will also be developed to evaluate passenger evacuation under various scenarios to identify and prioritize problem areas. Risk/benefit analyses, data bases, and evacuation models are the tools the working group will employ to set research priorities by evaluating the total cabin safety picture.

**Related Projects:** 061-110 Fire Safety, 062-110 Advanced Materials/Structural Safety, 067-110 Fire Research, and 086-110 Aeromedical Research. Capital Investment Plan projects: F-16 Technical Center Building and Plant Support and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

**Products:**

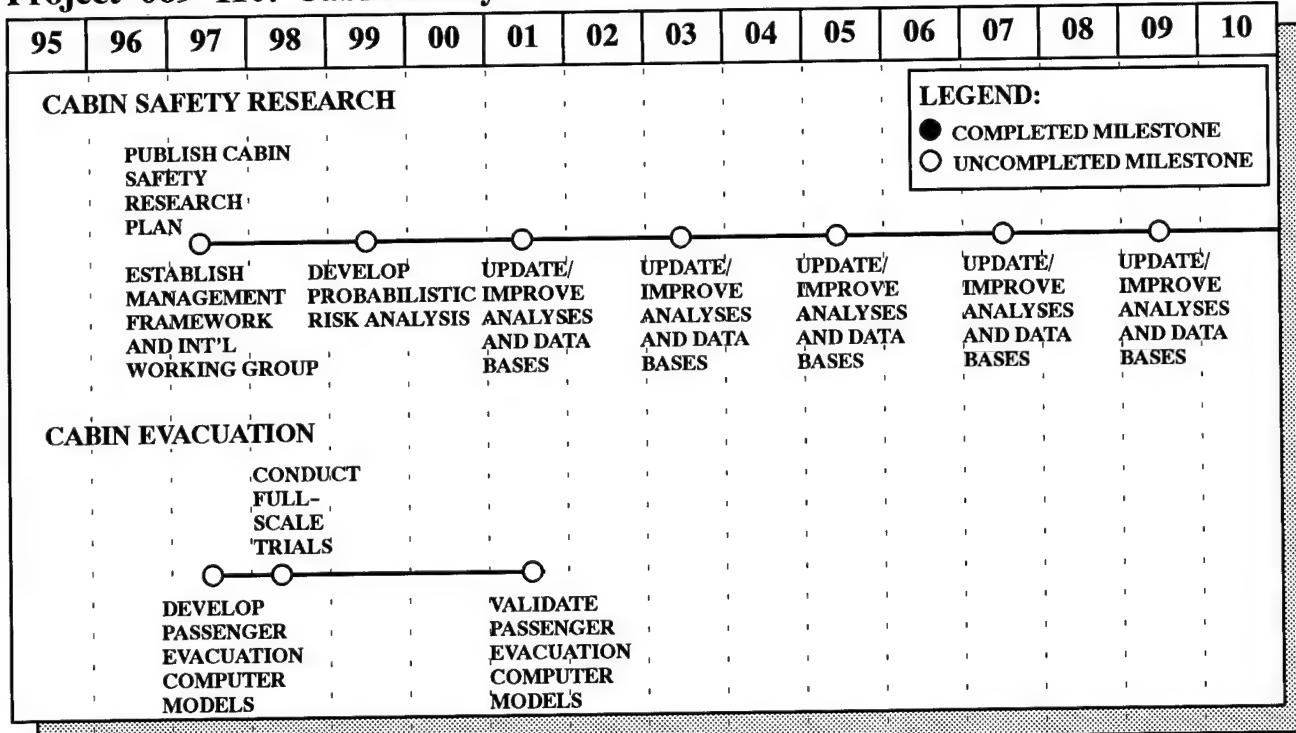
- Cabin Safety Research Plan
- International Conference on Cabin Safety Research and Development
- An international working group to coordinate cabin safety research
- Cooperative joint cabin safety research agreement among FAA, JAA, and TCA
- Cabin safety accident/incident data bases
- Cabin safety risk/benefit analysis models
- Passenger evacuation computer models

**1996 Projected Accomplishments:**

- Publish Cabin Safety Research Plan.

**Planned Activities:** In 1997, the FAA, JAA, and TCA will establish the management framework for the joint cabin safety research program. Decisionmaking tools such as the cabin safety data bases and the risk/benefit analyses will be continually updated and improved. A probabilistic risk analysis taking into account such factors as fleet growth and mix will be developed for use in 1999.

Full-scale aircraft passenger evacuation trials will be conducted during 1998 to evaluate newly developed computer models. Modifications of these models will continue until final validation in 2001. As confidence is gained in the accuracy of the models, the results will be used in the risk/benefit analyses.

**Project 069-110: Cabin Safety**

## 7.0 SYSTEM SECURITY TECHNOLOGY

This thrust area is driven by the requirement for a safe and secure aviation system. The direct benefit from an effective security system is preventing fatalities, injuries, and property losses resulting from intentional criminal acts. The indirect benefits include preventing a variety of disruptions to air traffic services and their attendant economic impact. Developing new security technologies is necessary to achieve a high security level without incurring excessive costs or inconvenience to the air transport industry or passengers.

Civil aviation continues to be an attractive target for terrorists or individuals with other criminal motives because it is highly visible. The threat level has evolved from hijacking in the mid-1970's to terrorist activities aimed at disrupting or destroying specific air transportation elements. The tragedy that befell the 270 victims of Pan Am Flight 103 over Lockerbie, Scotland, is one such act. In the United States, the immediate impact from this event was to double airline security costs from \$500 million to almost \$1 billion per year.

Even a threat on a specific target is sufficient to cause significant disruptions and economic impact. For example, events in the Persian Gulf during the first 3 months of 1991 reduced consumer confidence in the air transport system's security. As a result, scheduled air miles for domestic flights decreased by 5.2 percent, with international flight miles on U.S. carriers decreasing by 16.2 percent. Continued public confidence in the aviation system's security from terrorist threats, in general, and U.S. airports and carriers in particular, is key to the public using these services and the resulting economic benefits.

The Federal Aviation Administration initiatives in system security are designed to provide this confidence and achieve these benefits by developing systems that prevent or deter hijacking and sabotage. An initial thrust area assessment indi-

cates that benefits as high as \$40 million per year can be achieved from reduced airport security service costs while providing increased protection. The benefit from avoiding the direct costs of just one major incident would be approximately \$150 million for a wide-body aircraft plus \$450 million for the lives lost.

Research in security technology is needed to counter threats that are becoming more sophisticated. The spread of terrorism makes it imperative for the FAA to identify and develop the most effective technologies that can be practically applied in security systems. Those who pose a threat to the traveling public are intelligent, committed, and innovative, striking where the system is most vulnerable. Protection must therefore be comprehensive, addressing all potential vulnerability in the airport and air traffic control facilities, as well as onboard the aircraft.

The Aviation Security Improvement Act of 1990 directs the FAA to:

- Accelerate its system security program over a 36-month period;
- Expand its system security program to address current and future threats; and
- Expand the security initiatives in the aircraft hardening and human factors areas.

The continued emphasis for research in this thrust area has been on developing automated capabilities to prevent introducing explosives onto aircraft, and enhancing human performance in the system.

A broad agency announcement and solicitations for proposals have been used to identify and fund over 30 different organizations to conduct security-related Research, Engineering and Development (R,E&D). These contracting

mechanisms allow the FAA to identify and exploit innovative concepts and technologies from both industry and academia. Currently, explosive detection and pattern recognition research is underway.

The FAA's work in aviation security also involves cooperative efforts with many other Government agencies such as the Departments of State, Defense, and Energy; U.S. Customs Service; Bureau of Mines; and intelligence and law enforcement agencies. International working agreements to exchange security R,E&D information are in place with Canada, the United Kingdom, France, and Israel.

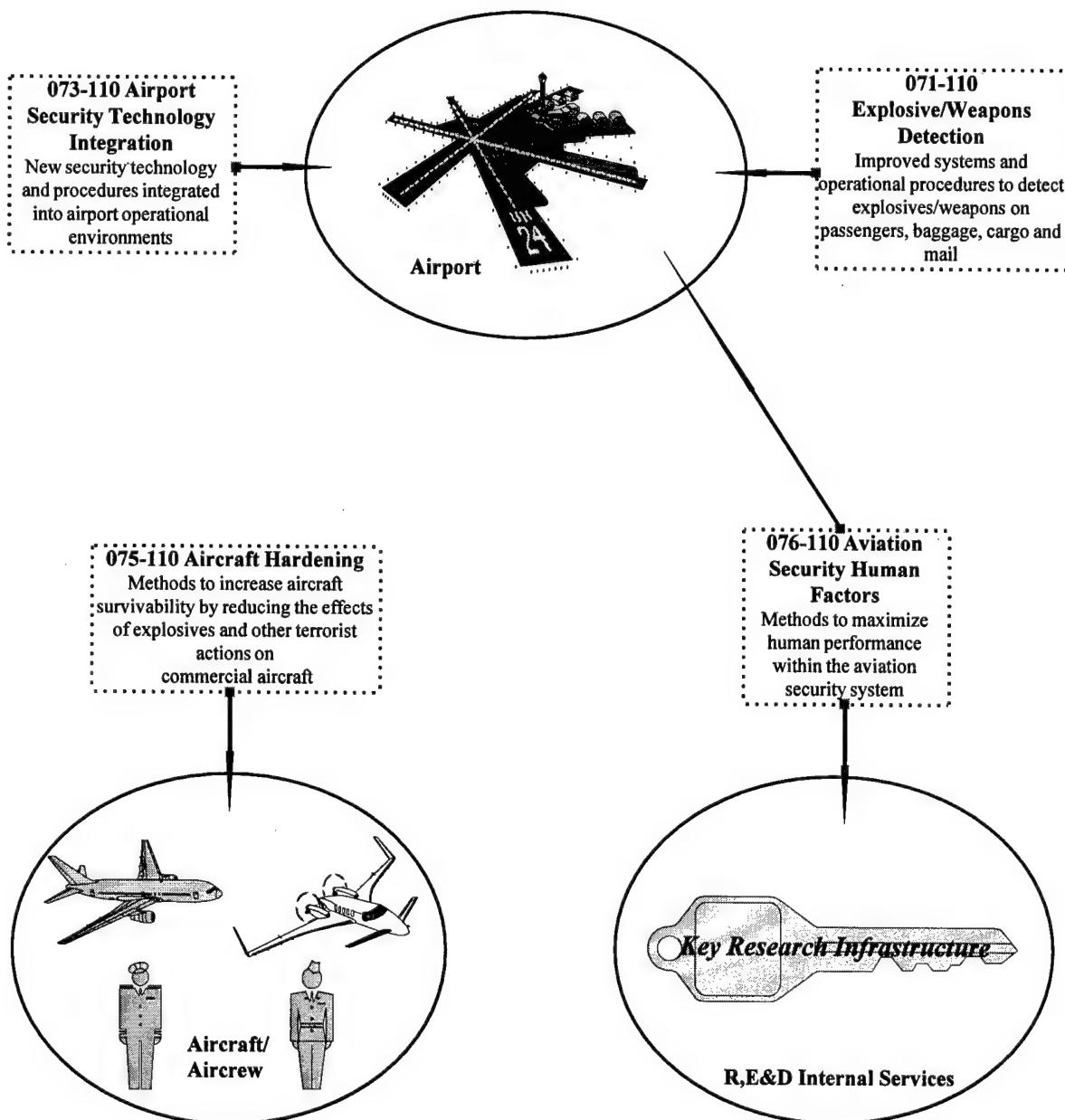
To support operational security systems deployment, the security R,E&D program includes

tasks to devise standard test protocol and performance criteria for testing automated explosives detection systems and for giving advice on credible systems architecture for various detection techniques. Technology assessments will be performed on commercially developed security equipment utilizing the standard test protocol, and a list of approved automated explosives detection technologies will be developed for implementation by air carriers.

The results from the Security R,E&D Program are technologies, specifications, rules, and guidance to be used by airports and air carriers to perform their aviation security functions. The FAA does not, except for human factors and air traffic control facility protection, procure the hardware that results from the Security R,E&D Program.

## System Security Technology Projects

### Contributions to FAA Services



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## 7.1 System Security Technology Project Descriptions

### 071-110 Explosives/Weapons Detection

**P**urpose: This project will develop improved systems and operational procedures for detecting explosives/weapons on passengers and in checked and carry-on baggage, air cargo, and mail. These improved, fully automated systems will allow rapid passenger and baggage screening to occur without interrupting passenger or baggage flow. These systems will have high detection rates with low false-alarm probabilities, thereby increasing airport and air carrier safety.

The current trend in firearm and some grenade manufacturing is toward using nonmetallic components and nonferrous alloys. These weapons may escape detection by current airport metal and weapon detection systems. This project will also develop screening systems based on alternative technologies that are capable of detecting "plastic" and other unconventional weapons.

#### Approach:

##### Explosives Detection

Current systems are intrusive and labor intensive. Design goals are for systems that are fast and effective and provide a uniform, high performance level through computer assistance. The challenge is to select sensor systems appropriate to the threat and scenario, then integrate them within the constraints of an airport.

The FAA is developing two basic types of explosives detectors. The trace detection program is designed to collect, analyze, and identify trace amounts of different explosives. Since they are passive devices, trace detectors are strong candi-

dates for screening passengers. The bulk detection program is designed to use electromagnetic energy or nuclear radiation to penetrate and identify bulk explosives based on their elemental or structural composition. In the near-term, both trace and bulk prototype detectors will be developed to provide an immediate response to today's terrorist threat. In the long-term, the emphasis will be on identification, feasibility demonstration, and subsequent development of more efficient and effective new technologies.

This project will focus on three major elements for screening checked baggage: developing prototype systems, developing combined technology prototypes, and developing new detection algorithms to upgrade existing detection systems. Several trace portals to screen passengers are in the development stage. Emphasis is being placed on developing methods and test objects that will be used in trace certification testing. Chemiluminescence and ion mobility spectroscopy have reached the commercial stage and are leading certification candidates. The trace detector program will also key on olfaction studies that include developing improved training and testing techniques as well as evaluating canine response to various explosives.

A computer tomography system has recently passed FAA certification as an explosives detection system. Further development is planned to improve this system's operational characteristics. Fast neutron radiography is now being investigated and will be brought to the demonstration stage. Component research on these technologies will continue.

## Weapons Detection

Methods to enhance current generation screening system performance are being investigated. Commercial weapons detection devices are being evaluated for deployment in airports, and new standards are being developed to ensure that these screening systems continue to be effective. Alternate methods to detect nonmetallic weapons and liquid explosives are also being investigated along with passenger screening systems.

**Related Projects:** 073-110 Airport Security Technology Integration, 075-110 Aircraft Hardening, 076-110 Aviation Security Human Factors, and 101-180 Aviation Research Grant Program. Capital Investment Plan projects: F-16 FAA Technical Center Building and Plant Support and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

### **Products:**

- Feasibility studies
- Prototype hardware
- Project evaluation reports
- Engineering procurement specifications
- Data to support rulemaking

### **1996 Projected Accomplishments:**

- Begin development of advanced X-ray system and the multi-view dual energy X-ray system.
- Conduct airport demonstrations of certified explosives detection system.
- Complete evaluation of commercial trace systems.
- Conduct airport test of trace passenger portal.

- Complete laboratory prototype trace cargo screener.
- Complete feasibility study for bulk cargo screening systems.
- Develop canine readiness field test.
- Complete trace electronics protocol.
- Conduct laboratory demonstration of a real-time millimeter wave nonmetallic weapons detection systems portal.
- Complete airport data collection on dielectric and nuclear magnetic resonance bottle screening systems.

### **Planned Activities:**

#### Explosives Detection

First-generation detection systems will continue to be deployed while new detection systems development, including prototype trace portals, will continue with operational testing scheduled from 1997 through 2000.

Nuclear research will focus on developing components, such as accelerators, targets, and detectors, through 1997. By 1997, testing will be performed on laboratory prototype systems for fast neutron spectroscopy/radiography and alternate multi-sensor systems designed for integration with compatible systems. In 1998, a baggage screening system simulation will be completed. Enhanced X-ray systems integration with trace and/or other technologies will be initiated and studied. In 1997, additional trace portal prototypes will be completed, and testing will begin at airports in the United States. Trace detection systems will be upgraded for new threats, and an automated trace baggage system will be built. A cargo container and mail nuclear/X-ray scanning system laboratory prototype will

be tested for explosives detection jointly with another agency in 1998.

In 1998, a laboratory prototype for the pulsed fast neutron cargo screening system will be completed, and a biotechnology trace detector prototype for area screening will be tested. An integrated trace, bulk, and new threat detection system for baggage inspection will be developed in 1999 to replace multiple detection systems in airports.

In 1998, an automatic high-volume passenger scanning portal will be developed to combine explosives and weapons detection systems. Also in 1998, an airport test of a trace cargo screening system will be conducted. In 1999, a prototype standoff trace detection system will be developed to detect large explosive devices.

#### Weapons Detection

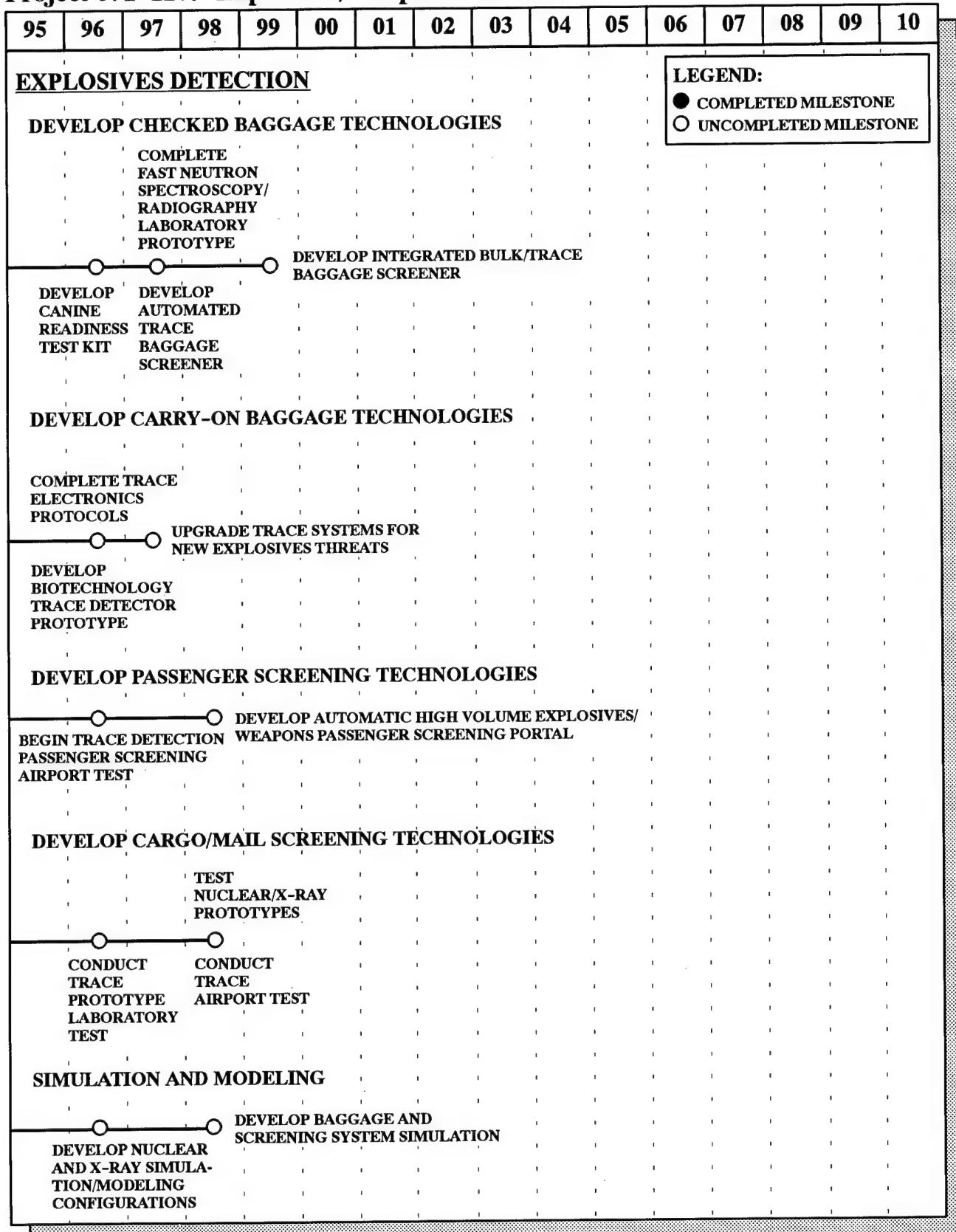
In 1997, lessons learned from the linear array technology will continue to be applied to the real-time millimeter wave system portal. A prototype real-time millimeter wave passenger scanner will be evaluated in the laboratory and tested at an airport. Also in 1997, bottle screening certification standards will be published.

In 1998, an automatic high-volume passenger scanning portal will be developed to combine explosives and weapons detection systems and then tested in the laboratory.

#### Emerging Technologies

New technologies will be identified and developed based on emerging threats, and those showing promise will be operationally tested in the laboratory and airports. Broad agency announcements, the grants program, or similar vehicles will continue to identify innovative approaches to this challenging problem, and synergistic combinations of the sensor systems identified will be examined.

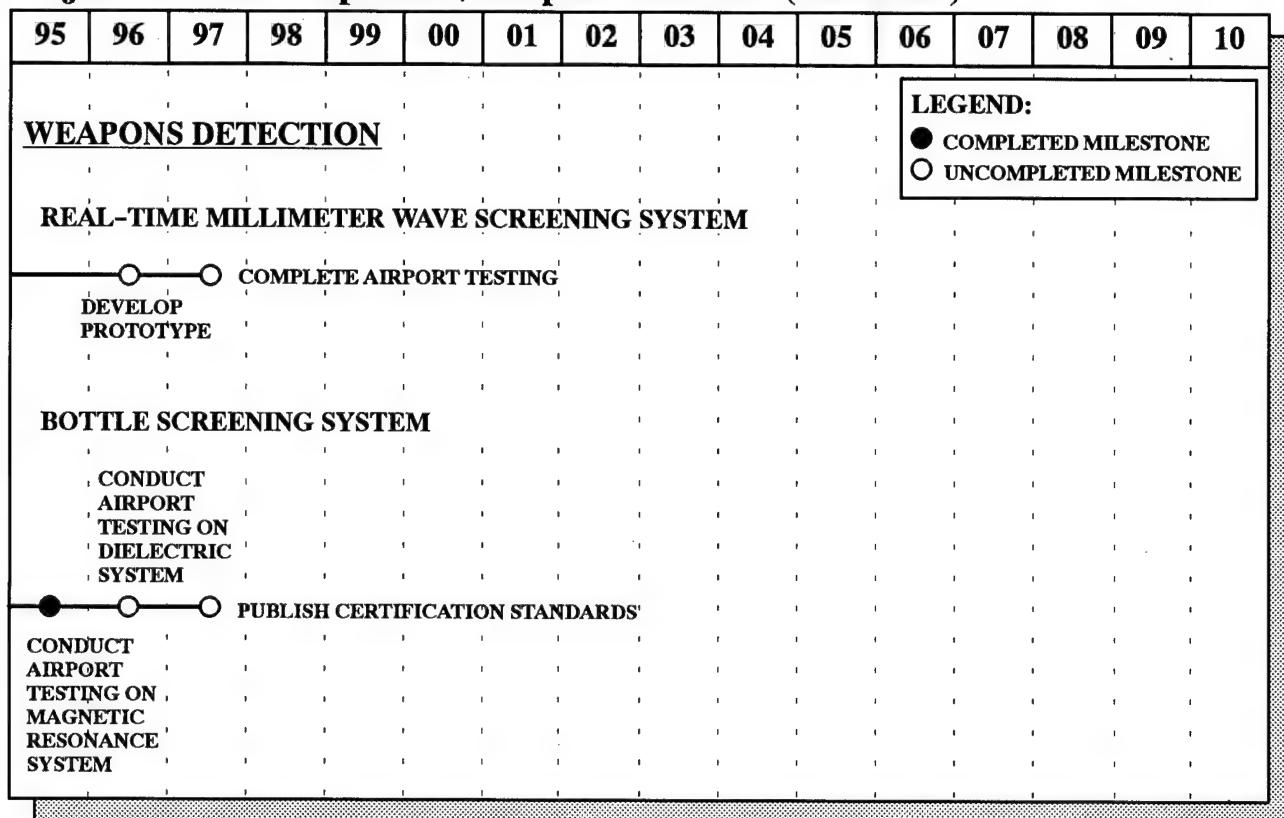
# Project 071-110: Explosives/Weapons Detection



## LEGEND:

- COMPLETED MILESTONE
- UNCOMPLETED MILESTONE

## Project 071-110: Explosives/Weapons Detection (continued)



## 073-110 Airport Security Technology Integration

**P**urpose: This project will determine the operational effectiveness, impact, and cost for enhanced airport security by using demonstration airports. Establishing demonstration airports will provide real-time testbeds for evaluating new security technology and procedures integrated into operational environments.

This project also will evaluate airport security from a systems approach, determine if current systems integration is adequate, identify alternatives to counter evolving security threats, and identify additional requirements for research and development. A cost-effective and unobtrusive security system will become an integral part of

normal civil aviation operations resulting from the various security research efforts that are currently underway.

**Approach:** Technology and procedures system integration and operational testing will determine whether new technologies and procedures are ready to be implemented in the operational aviation system, or whether further development is needed. New or enhanced training and operational procedures will be validated. Additionally, operational test results will be evaluated against threat/risk assessment and requirements definition to determine if the R,E&D products meet the objectives.

Protection for airport targets has been prioritized based on current and predicted future terrorist threats. The prioritized targets have been correlated with existing FAA regulations and actual airport security plans. Enhanced system design and operational procedures will be developed to counter higher threat levels while maintaining economic viability, responsiveness, and normal passenger flow. New security designs and operational procedures will be implemented and evaluated in a testbed environment at domestic and international airports as needed. These testbeds will be used to test new technology in an operational environment for performance characteristics and operational procedures through cooperative research and development agreements with the aviation industry. Successful equipment will be considered for use throughout the system as appropriate.

This project will interpret and translate threat information into functional security system requirements using accepted analytical methods and tools. Modeling and applied research necessary to define security system parameters and constraints will be conducted. The model will contain information on current and future threats as well as technologies to counter each threat.

A long-range, strategic plan for developing and deploying aviation security system components will be developed to ensure that all components, attributes, and relationships needed to achieve a higher security level are identified and integrated into the system.

Alternative security system design approaches will be evaluated through system cost-effectiveness analyses and tradeoff studies. A feedback mechanism will be established for updating system requirements on a continuing basis as new threat or technology issues are identified through intelligence activities, research developments, and/or operational equipment and procedures testing.

**Related Projects:** 051-110 Airport Planning and Design Technology, 071-110 Explosives/Weapons Detection, 076-110 Aviation Security Human Factors, and 101-180 Aviation Research Grant Program. Capital Investment Plan projects: F-15 General Support Laboratory Sustained Support, F-16 FAA Technical Center Building and Plant Support, and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- Airport vulnerability reports based on current and future threat definitions
- Integrated airport security conceptual design
- Upgraded airport security testbeds
- Test and evaluation reports
- Operational procedures, guidelines, training curricula, and effectiveness measures
- New operations concepts and system requirements for integrated enhanced airport security responses to threats
- Analytic models for threat, risk, vulnerability, and cost/benefit assessment
- Long-range strategic plan for research, design, development, and deployment of enhanced integrated airport/aviation security systems

#### **1996 Projected Accomplishments:**

- Develop security technology standards.
- Host annual task force planning group to identify technologies for countering aviation industry threats, and publish classified report.

- Develop analytical models for threat/risk/vulnerability assessment.
- Transfer radio frequency technology for baggage and passenger tracking to industry.

**Planned Activities:** An analysis process will be used to evaluate countermeasures and initiate requirements for research and development as new advanced threats emerge. Opportunities for new testbed installations will be investigated at various airports, taking advantage of existing or ongoing construction projects.

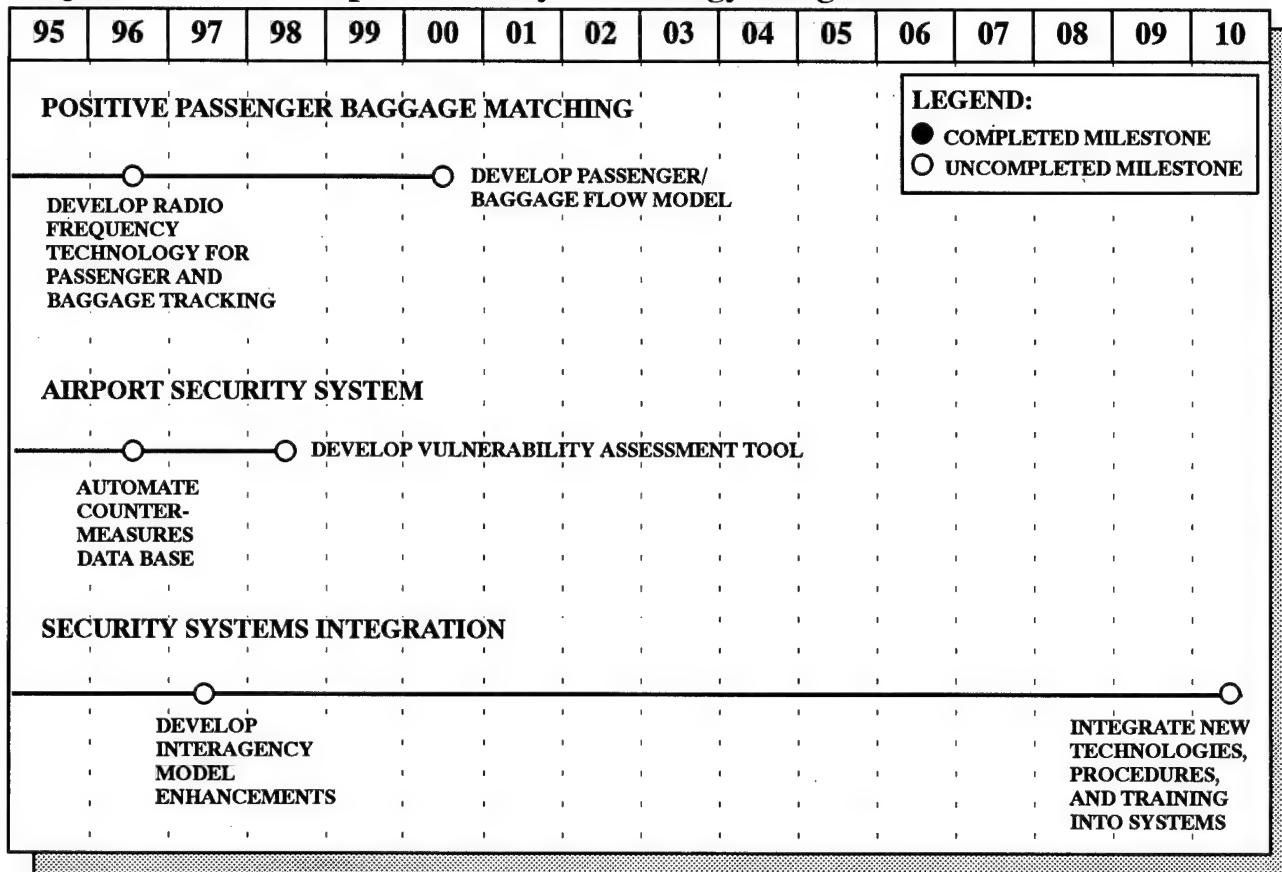
In 1997, threat/risk model work with other government agencies will continue, and interfaces

with other government agency systems will be expanded. This work will continue through 1998. Sensor integration analytic evaluations will be performed as new technologies emerge.

Annually, reports on countermeasures for new advanced technical threats will be published. In 1998, an airport security vulnerability assessment tool will be completed.

In 2000, a passenger and baggage flow model will be developed to simulate the effects of security enhancements in the airport environment. Work will continue through 2010 for security integration and training. Analytic evaluations will be performed as new technologies emerge.

### Project 073-110: Airport Security Technology Integration



## 075-110 Aircraft Hardening

**P**urpose: This project will identify methods to increase aircraft survivability by reducing damage effects caused by a small explosive detonation on a commercial airliner. The threat to commercial aircraft and passenger survival due to the in-flight detonation of a small explosive device is significant. Balancing current technology detection capability and aircraft hardening to withstand damage from a detonation in flight will be accelerated, as required by the Aviation Security Improvement Act of 1990. In addition, the program is assessing possible terrorist threats to civil aviation caused by projected energy beams, mobile surface-to-air missiles, and specifically directed electromagnetic sources.

**Approach:** Blast loading parameters caused by various explosive types and quantities will be determined. Models will be developed to predict damage to an aircraft resulting from explosive detonations. Explosives testing will be conducted on aircraft and/or other test devices to verify models and assess damages using various scenarios. These tests will also be used to help determine aircraft vulnerability and validate blast mitigation/structural hardening techniques. Additionally, testing will be used to evaluate least-risk guidelines. Once failure mechanisms are identified, methods to protect an aircraft against catastrophic structural failure due to an in-flight explosion will be developed. To assess the civil threat from projected energy beams, electromagnetic sources, and surface-to-air missiles, this project will use the extensive capabilities of the Department of Defense and other agencies.

**Related Projects:** 064-110 Flight Safety/Atmospheric Hazards, 065-110 Aging Aircraft, 066-110 Aircraft Catastrophic Failure Prevention Research, 071-110 Explosives/Weapons Detection, and 101-180 Aviation Research Grant Program. Capital Investment Plan projects: F-16 FAA Technical Center Building and Plant Support and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

### Products:

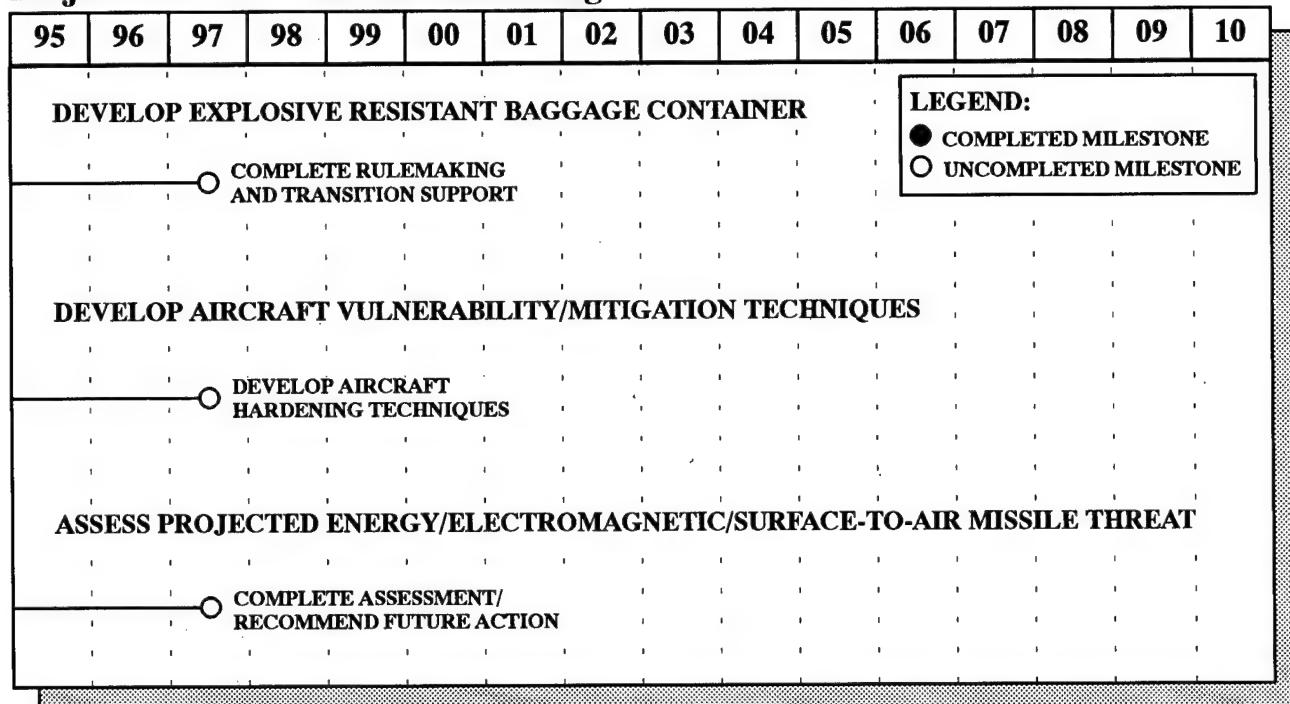
- Project evaluation reports
- Prototype hardware
- Guidelines for blast mitigation/aircraft hardening
- Engineering design specifications for aircraft and support equipment
- Threat assessments on different terrorist weapons

### 1996 Projected Accomplishments:

- Provide support for hardened container rulemaking activities to include operational in-use assessments.
- Validate wide body vulnerability through actual aircraft blast tests.
- Identify and validate mitigation techniques for projected energy, electromagnetic, and surface-to-air missile threats.
- Transition all container-related research data to the private sector.
- Analyze data from ongoing prototype hardened container demonstrations.

**Planned Activities:** In 1997, if appropriate, data in support of aircraft design rulemaking will be acquired for the explosive, electromagnetic, projected energy, and surface-to-air missile threats. Specifications and standards for hardened containers will be refined, and other innovative hardening techniques will be investigated and validated. An assessment will also be made on emerging threats, and a plan to investigate counter methods will be developed, if needed.

## Project 075-110: Aircraft Hardening



## 076-110 Aviation Security Human Factors

**P**urpose: This project carries out the mandate of the Aviation Security Improvement Act of 1990, Public Law 101-604. This law's intent is to "maximize human performance" within the aviation security system and "include research and development of both technological improvements and ways to enhance human performance."

**Approach:** This project addresses three primary areas: human systems integration for new equipment designs, security system and operational procedures development and testing, and security personnel selection, training, and performance monitoring. A key element is leveraging research and collaborating with other government agencies, the aviation industry, and academia.

The screener enhancement project will focus on an airport demonstration of the screener proficiency evaluation and reporting system (SPEARS) technology for enhancing operator acquisition and sustainment training as well as performance monitoring. SPEARS has completed operational test and evaluation to determine deficiencies and identify additional research requirements. The airport demonstration will be follow-on operational tests and evaluations conducted to confirm full functional capability.

An airport demonstration will also be conducted with computer assisted tomography (CAT) scan technology. This demonstration will evaluate systems for associated acquisition and sustainment training as well as performance monitoring.

The passenger profiling project will expand an automated domestic passenger profiling capability that analyzes a set of parameters determined by an interagency panel of security experts. This system will identify passengers requiring additional security screening. Implementation strategies will be determined for both active and passive profiling techniques. Also, this project will evaluate how acceptable increased security measures are to the flying public relative to costs and delays.

Human systems integration will address the human characteristics required to interface with security screening equipment resulting from emerging technologies. This project focuses on conducting assessments, developing procedures, and testing technologies for the various security areas within an airport environment. An important element of this research will be evaluating the complexity of multiple positions at a futuristic screening checkpoint for passengers and carry-on baggage.

**Related Projects:** 071-110 Explosives/Weapons Detection, 073-110 Airport Security Technology Integration, and 101-180 Aviation Research and Grant Program. Capital Investment Plan projects: F-15 General Support Laboratory Sustained Support, F-16 FAA Technical Center Building and Plant Support, and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- SPEARS category-X airport testing and recommendations for implementation
- CTX 5000 CAT scan airport testing and recommendations for implementation
- Human systems integration analyses and reports on new explosives and weapons detection technologies
- Automated domestic profiling system

- Recommendations, guidelines, and regulatory packages for security training

#### **1996 Projected Accomplishments:**

- Expand automated domestic profiling system.
- Develop active and passive profiling techniques and determine their domestic implementation considerations.
- Complete category-X airport demonstration operational test and evaluation of SPEARS candidates.
- Complete CAT scan airport demonstration operational test and evaluation.

#### **Planned Activities:**

##### Human Systems Integration

In 1997, a report will be published on recommendations for application of passenger screening technologies. As new technologies emerge they will be periodically evaluated as countermeasures.

##### Passenger Profiling

In 1997, an international automated profiling system will be expanded to include all passenger reservation systems. Domestic and international profiling systems will be integrated in 1998.

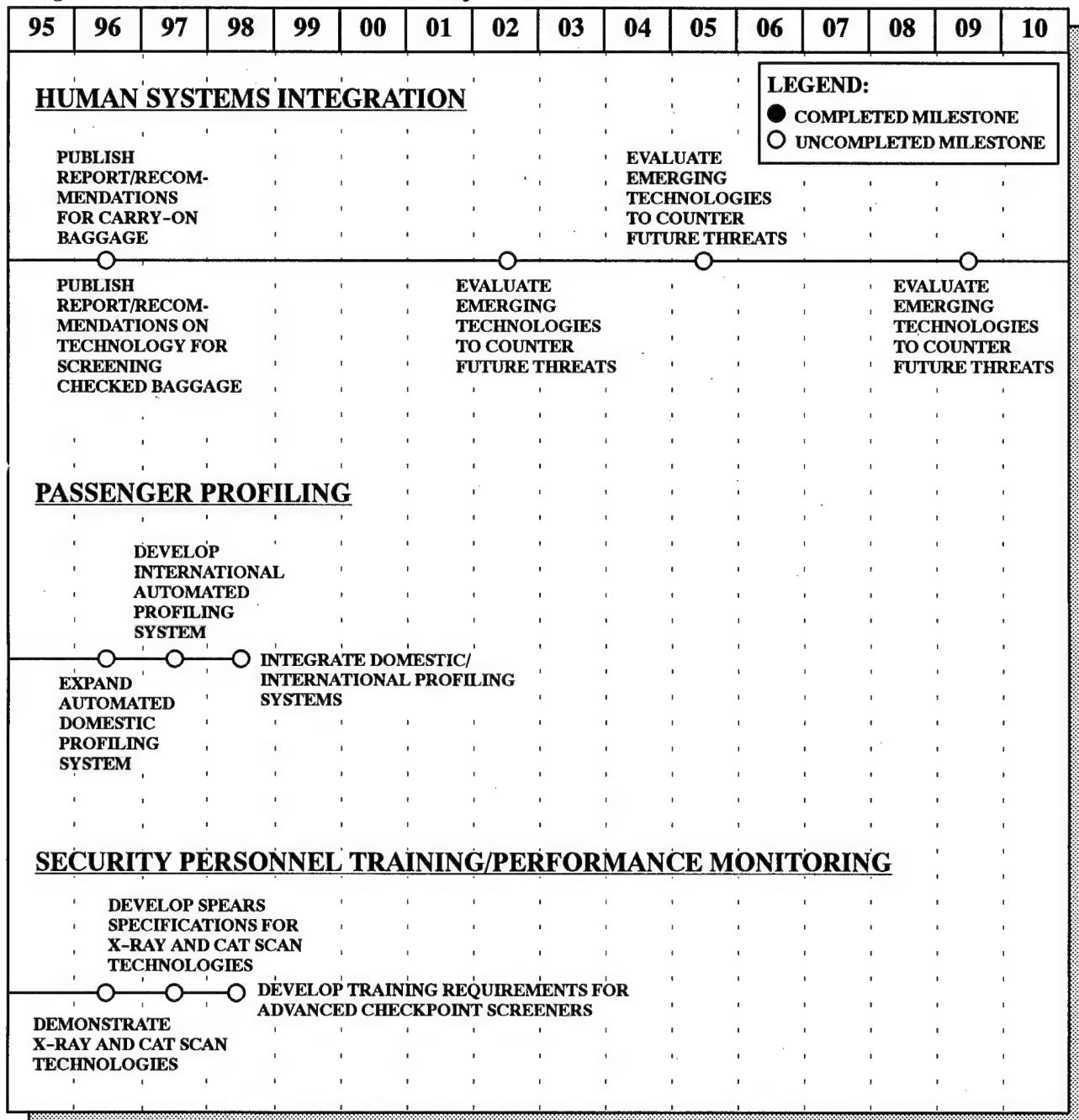
In 1997, security training programs will be published.

##### Security Personnel Training/Performance Monitoring

In 1997, final SPEARS specifications will be developed for both X-ray and CAT scan technologies. Training requirements for advanced checkpoint screeners will be developed in 1998.

As new system and personnel security threats emerge, technologies will be periodically developed and evaluated to counter these threats.

## Project 076-110: Aviation Security Human Factors



## 8.0 HUMAN FACTORS AND AVIATION MEDICINE

The human operator's role across all components of the National Airspace System (NAS) is critical to safe and efficient system operations. Advances in technology have increased the reliability of most system components, but the percentage of human error-related incidents and accidents has remained fairly constant. Historically, flight crew error has been cited as a contributing cause in over 60 percent of jet transport accidents, and the impact of human error is even higher when air traffic controllers, dispatchers, maintenance workers, and others are factored in.

Public, industry, and government concern for the human element in system performance resulted in Congress enacting the Aviation Safety Act of 1988 (Public Law 100-591), that called for the FAA to augment its research efforts in human factors and to coordinate programs with the National Aeronautics and Space Administration (NASA). The National Plan for Civil Aviation Human Factors: An Initiative for Research and Application published in 1995, hereafter referred to as The National Plan For Civil Aviation Human Factors, represents the most current effort to strategically address human factors research requirements.

The research projects in this chapter directly support this Plan and the validated needs of internal and external users. These projects address major human factors priority areas related to: flight deck, air traffic control (ATC), flight deck/air traffic control system integration, airway facilities, aircraft maintenance, and aeromedical-aircraft cabin environments. These areas are:

### Human-Centered Automation

Human-centered automation research focuses on the role of the operator and the cognitive and behavioral effects of using automation to assist humans in accomplishing their assigned tasks for increased safety and efficiency. The research in this area addresses the identification and application of knowledge concerning the relative strengths and limitations of humans in an automated environment. It investigates the implications of computer-based technology to the design, evaluation, and certification of controls, displays, and advanced systems.

### Selection and Training

Research in this area strives to understand the relationship between human abilities and aviation task performance; to enhance the measures and methods for the prediction of future job/task performance; to develop a scientific basis for the design of training programs, devices, and aids; to define criteria for assessing future training requirements; and to identify new ways to select aviation system personnel.

### Human Performance Assessment

The major objectives of the research in this thrust are to identify the intrinsic characteristics of individual and teams that determine how well they are able to perform aviation tasks; to characterize the impact of environmental and individual factors on human performance; and to improve and standardize methods for measuring human performance.

### Information Management and Display

Research in this thrust addresses the presentation and transfer of information among components in the NAS. It seeks to identify the most efficient and reliable ways to display and exchange information; to determine what, when, and how one might best display and transfer information to system components; to design the system to reduce the frequency of information transfer errors and misinterpretations; and to minimize the impact when such errors do occur.

### Bioaeronautics

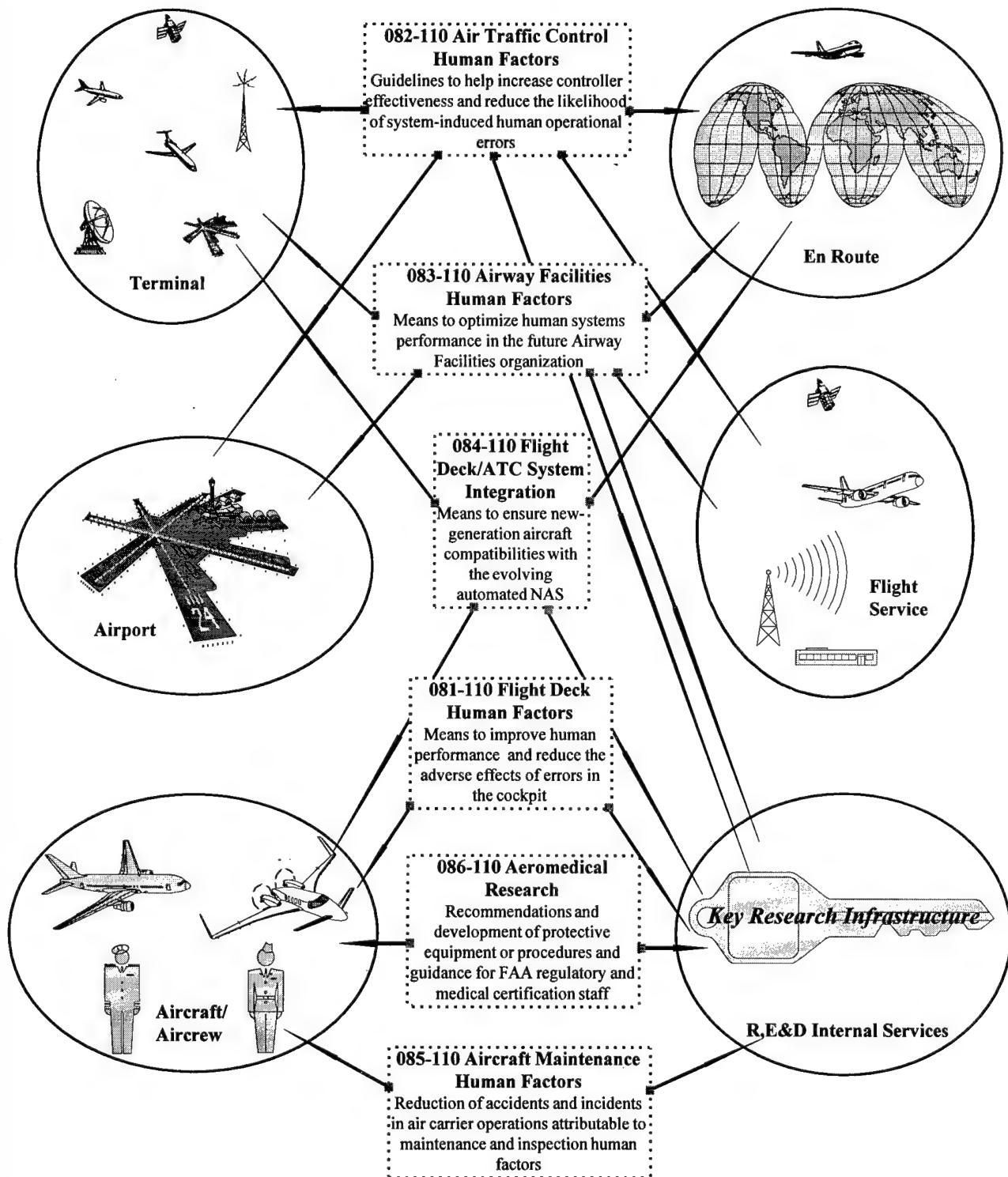
Bioaeronautics involves the bioengineering, biomedicine, and biochemistry associated with performance and safety. The objective is the enhancement of personal performance and safety by maximizing crew and passenger health and physiological integrity.

### Summary

The research projects in this chapter generally produce information as opposed to hardware. This information will continue to influence systems design, certification and regulation decisions, operations directives, and training procedures. The ultimate result is a safer and more efficient NAS Operation.

# Human Factors and Aviation Medicine Projects

## Contributions to FAA Services



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## 8.1 Human Factors and Aviation Medicine Project Descriptions

### 081-110 Flight Deck Human Factors

**P**urpose: This project will improve human performance and reduce the adverse effects of errors in the cockpit through improved systems design, procedures, and training. An important element in this research is, when possible, applying existing knowledge of human capabilities and limitations to the flight deck environment. Where existing knowledge is inadequate, this project will develop a better understanding of human performance factors. Statistics show that approximately 65 percent of all fatal civil air transport accidents and a higher proportion of general aviation (GA) accidents list human error as a probable cause. Since flightcrew errors contribute to the majority of aircraft accidents, a continuing program directed toward improved flight deck human engineering, flightcrew performance standards, airman selection, and initial and recurrent training can pay for itself many times over by preventing a single accident. New technology developments and better flightcrew performance using existing technology will provide further benefits by increasing operational efficiency.

**Approach:** The FAA and NASA share the responsibility for research in this project. Some of the current work is being accomplished under NASA's Aviation Safety/Automation Program, and some work is being accomplished as a collaborative effort. An important focus for the project is responding to relatively short-term requirements from sponsor organizations. A long-range goal is to develop the corporate human performance knowledge base that will scientifically support future rulemaking and safety programs.

Analytical, laboratory, simulation, and flight operational studies will be conducted in the following National Plan for Civil Aviation Human Factors areas: human-centered automation,

human performance assessment, selection and training, and information management and display. Information in data bases will be used to analyze the effects of selected human factors improvement methods, training, individual and operational stressors, and implementing increased automation. Research reports, conferences, and direct assistance to operational organizations will be used to support operational evaluations and develop advisory circulars, technical standard orders, and Federal Aviation Regulations (FAR) changes. Participation in technical committees such as the Society of Automotive Engineers will assist with developing industry practices and standards.

**Related Projects:** 022-140 General Aviation and Vertical Flight Program, 082-110 Air Traffic Control Human Factors, 084-110 Flight Deck/ATC System Integration, and 086-110 Aeromedical Research.

#### Products:

- Guidelines for the human factors design, evaluation, and certification of advanced technology flight deck displays and control systems
- Research data base integrating information on pilot medical history, age, prior experience, airmanship history, and information on accidents and incidents
- Pilot and flightcrew behavioral coding techniques that can be used to assess flightcrew training program effectiveness
- Guidelines for improved training programs in crew resource management, including aeronautical decisionmaking, team situational

awareness, and leadership/followership strategies

- Guidelines for selecting and training pilot instructors/evaluators
- Guidelines for line-oriented flight training scenario development and assessment
- Training guidelines for appropriate monitoring behaviors for pilot not flying
- Guidelines for qualifying flight training devices and simulators for training/airman certification
- Refined model advanced qualification program (AQP) for FAR Part 135 and Part 121 operators, and flight training centers, to include ab initio and recurrent crew training and assessment requirements
- Specification of integrated navigation displays and memory aids that provide cost-effective options to GA pilots for reducing risk exposure and enhancing pilot performance

#### **1996 Projected Accomplishments:**

- Complete beta test for prototype automated performance measurement system (APMS) with two U.S. air carriers.
- Develop model AQP for training centers to support regional air carrier involvement.
- Determine requirements for the modification of a level 5 flight training device to make it serve the same function as a level 7 flight training device.
- Develop guidelines for effective crew performance debriefing in line-oriented flight training.
- Identify flight crew leadership/followership skills for training course development.

- Specify minimum requirements for electronic chart formats for use in terminal area procedures.
- Evaluate the effectiveness of alternative course-deviation-indicator display formats for minimizing flight technical errors in terminal operations.
- Define human factors considerations for the use of ground collision avoidance system displays.
- Develop pilot performance data through flight simulation for use in establishing certification standards for autonavigation and control systems.

**Planned Activities:** In 1997, work will be accomplished to define critical issues regarding information displays and decisionmaking for pilots in the terminal area under free flight procedures. Additional research will produce minimum requirements for ground collision avoidance system alerting displays. Research also will be conducted through 1998 to define flight data management system high frequency issues and analyze sensor architectures. This research will lead to a flight data sensor integration report in 1998 with recommendations for integrating aircraft sensor inputs with controller automation systems.

In 1997, development work will continue on an APMS for evaluating training program effectiveness. An advanced prototype will be completed in 1998, followed by operational evaluation and validation leading to advanced APMS specifications for airline use in 2000.

In 1997, a model AQP for FAR Part 135 and Part 121 operators will be refined, and a draft AC120-54 revision on AQP will be developed for the approval process. AQP research will continue on a refined model AQP for Part 121 and 135 operators with completion expected in 2000. In 1997, a software tool to analyze AQP

crew performance data will be developed. In conjunction with this analysis tool, line-oriented flight training scenario designs will be developed to address training deficiencies.

In 1997, work will continue on research to develop team training guidelines. This research will focus on crew decisionmaking and situational awareness processes. Research will continue throughout 1998 when training guidelines will be issued. This research will also study the decisionmaking process among dispatchers, air traffic controllers, and pilots. Research will continue through 1999 and will address free flight implications for systematic decisionmaking.

From 1997 through 2000, systematic research efforts will quantify the performance transfer for level 1-7 flight training devices, and level A-D certification/training recommendations will be completed. This research is needed to establish the allowable credit for training and checking tasks when using a flight training device in place of actual aircraft flight training and testing.

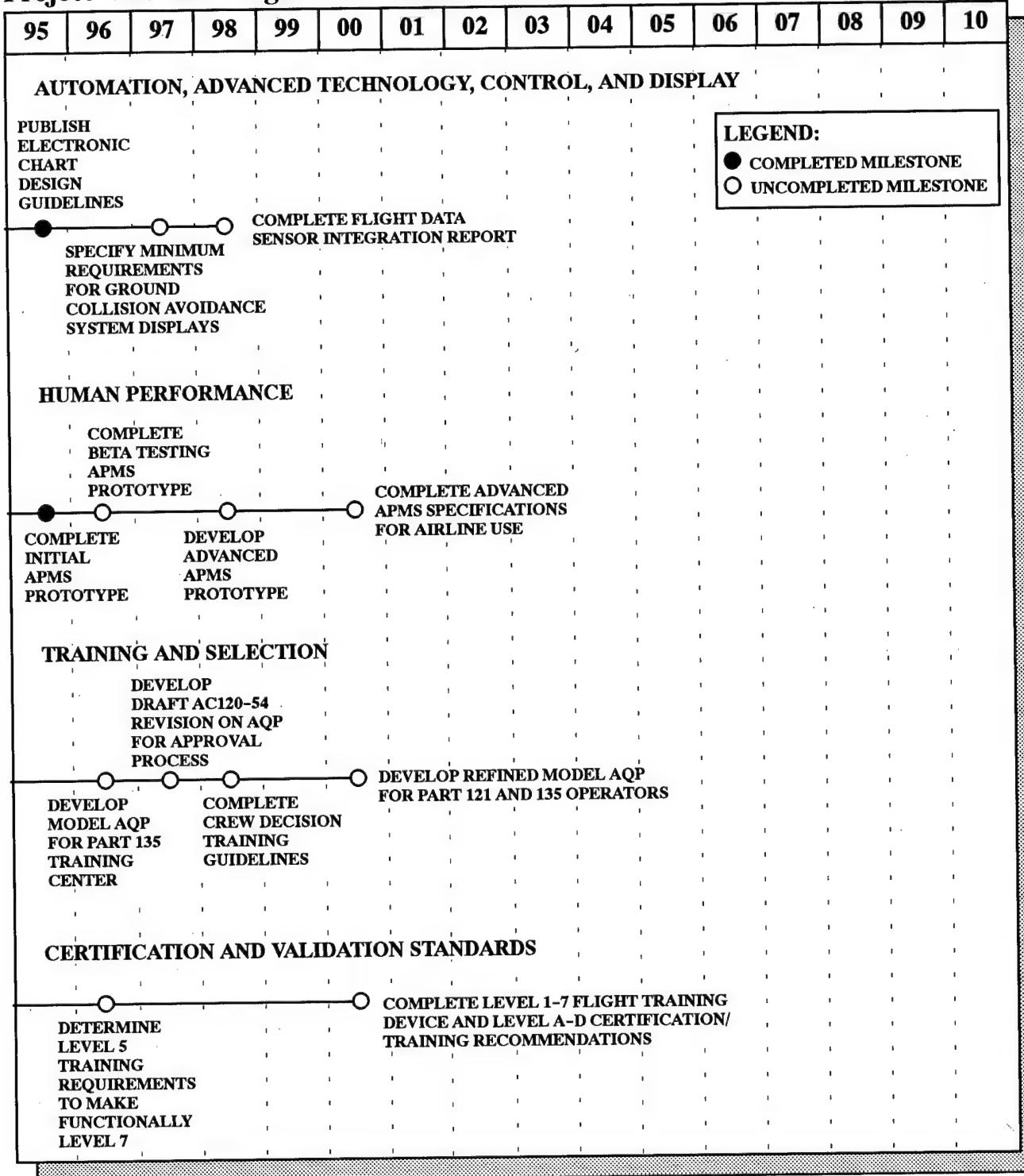
In 1997, research will continue on producing objective data on air crew performance. This

information will be used to produce certification guidelines and data to support regulation decisionmaking relative to aircraft design for the general aviation community.

In 1997, general aviation research will continue to collect scientific data to aid in identifying equipment design and pilot training initiatives. Human factors guidelines will be developed to assess cockpit integration of advanced navigation and alerting systems and to assess the effects of head-up displays in GA cockpits. Work will continue on developing data to assess the effects of pilot aging on performance and to determine task-based requirements for transitioning GA pilots from simple to complex aircraft.

From 1997 through 2000, high fidelity simulation research will continue on relevant GA problems to obtain objective, scientifically derived data to aid in identifying affordable options for reducing GA pilot risk exposure and the number of incidents and accidents in the general aviation community. Using flight simulation, guideline data will be developed for application to the cockpit design of the advanced general aviation transport experiments aircraft.

# Project 081-110: Flight Deck Human Factors



**LEGEND:**

- COMPLETED MILESTONE
- UNCOMPLETED MILESTONE

## 082-110 Air Traffic Control Human Factors

**P**urpose: Statistics show that human error is a probable cause in over 65 percent of aviation accidents. The FAA has recognized the role of human factors in operational errors, and the fact that human factors considerations are critical to the effective design, integration, and evaluation of equipment and procedures for use in air traffic operations. This project will improve human performance by providing guidelines to help increase controller effectiveness and reduce the likelihood of system-induced human operational errors.

**Approach:** The Air Traffic Control Human Factors project operates in consonance with other FAA strategic and program plans as well as the National Plan for Civil Aviation Human Factors. This project is designed to increase air traffic control system safety and efficiency by: applying human factors to designing and integrating new air traffic control equipment and procedures; exploring human perceptual capabilities and limitations as they relate to ATC systems; studying operational error causes and providing recommendations to reduce their frequency; developing standards and guidelines for applying human factors engineering to ATC system acquisition and evaluation; developing performance measurement methods and criteria for ATC system applications; determining automation's effect on controller work activities, performance, and productivity; and studying new technologies to improve controller selection and training.

An important by-product of all efforts in this project is developing reference information on human factors that can be applied in formulating future operational requirements. It is imperative that human factors be considered at a program's inception and integrated throughout its developmental lifecycle. Conducting human factors research early in the development process will

help identify design deficiencies when they are easier to correct and prevent fielding systems that have the potential to induce operator error.

Analyses on organizational and environmental factors affecting controller performance will provide data leading to innovative methods for improving safety and productivity. Situational factors and human systems characteristics affecting the controllers' job performance will provide performance-based feedback tools that management can use to assess the results of change in the environment.

Detailed job task analyses, training evaluations, and performance assessments will be conducted across the ATC system operations spectrum. This research will enable the FAA to effectively accommodate evolutionary changes in the ATC system. The result will be ATC personnel systems closely integrated with, and reflecting the operational requirements of future, highly automated ATC systems.

A related effort is developing and validating performance measures sensitive to controller workload and decisionmaking. This effort will enable the FAA to determine objectively whether given ATC systems and equipment are beneficial to controller performance.

Assessing the impact of automation on controllers will provide insights into the complex interaction between man and machine. The result will be guidelines to help the FAA ensure that automated systems fully support air traffic controllers, minimize human error probability, and maximize both safety and efficiency.

**Related Projects:** 081-110 Flight Deck Human Factors, 084-110 Flight Deck/ATC Integration, and 086-110 Aeromedical Research.

### **Products:**

- Human factors requirements guidelines for designing, integrating, and evaluating ATC systems for human operators
- Analysis tools and standards for assessing/predicting controller work activity and performance.
- Guidelines and models for optimally allocating operational functions and tasks to controllers and their equipment
- Real-time simulations, rapid prototyping, computational models, and reference data that support FAA specifications, acquisitions, and tests for improving air traffic control equipment and procedures
- Capability to reconstruct en route operational errors and incidents
- Tools and reference information for improved performance-based controller selection, training, certification, and retention

### **1996 Projected Accomplishments:**

- Evaluate measures of air traffic controller performance that will be used to baseline the effectiveness of current ATC systems as well as to predict, through simulation, the impact of proposed system changes.
- Determine the efficacy of using generic sectors as research tools in performance research.
- Complete training needs analysis focused on the tower cab environment.
- Develop initial model of teamwork measures for the en route environment.

- Complete systematic air traffic operations research initiative (SATORI) user guide for the terminal radar approach control (TRACON) environment.
- Develop baseline measures of controller situational awareness in the en route environment.
- Develop fatigue countermeasures guidelines.
- Publish electronic version of Human Factors in the Design and Evaluation of ATC Systems.

### **Planned Activities:**

#### Air Traffic Controller Selection and Training

In 1997, long range research will center on determining the most effective way to incorporate new technologies into the selection, training, and certification of air traffic controllers. Selection projects will continue to address the need to screen future applicants based upon the role they will assume in the next-generation, highly automated ATC system. Job task analyses currently underway will lay the necessary ground work. In 1997, guidelines for assessing teamwork skills will be available for use in the selection process. Also in 1997, training interventions to enhance tower cab team decisionmaking skills will be finalized and disseminated.

From 1997-1998, research will continue on enhanced controller selection and screening methodologies. These methodologies will undergo a testing and validation period through 2001, followed by a decision point on implementation. This effort will also evaluate innovative technologies such as interactive CD-ROM, voice recognition, and holographic displays from 1997-1999. In 2000, development will then proceed on those technologies that have the most potential for training/screening applications.

## Human Performance

In 1997, research into air traffic controller performance will continue. By 1998, these measurement tools will be available to establish a performance baseline. From 1998 to 2000, performance metrics will be refined and published in handbook form.

In 1998, the effectiveness of countermeasures to combat rotating shift-induced fatigue will be evaluated in field settings.

In 1997, research into new applications for the SATORI tool will continue. SATORI will be used to develop measures of TRACON personnel taskload and performance. From 1998 to 1999, SATORI software will be modified to support future systems. Emphasis will be placed on identifying sources of human error and developing a checklist for use in analyzing operational errors. In 1999, intervention strategies will be developed for the reduction of operational errors.

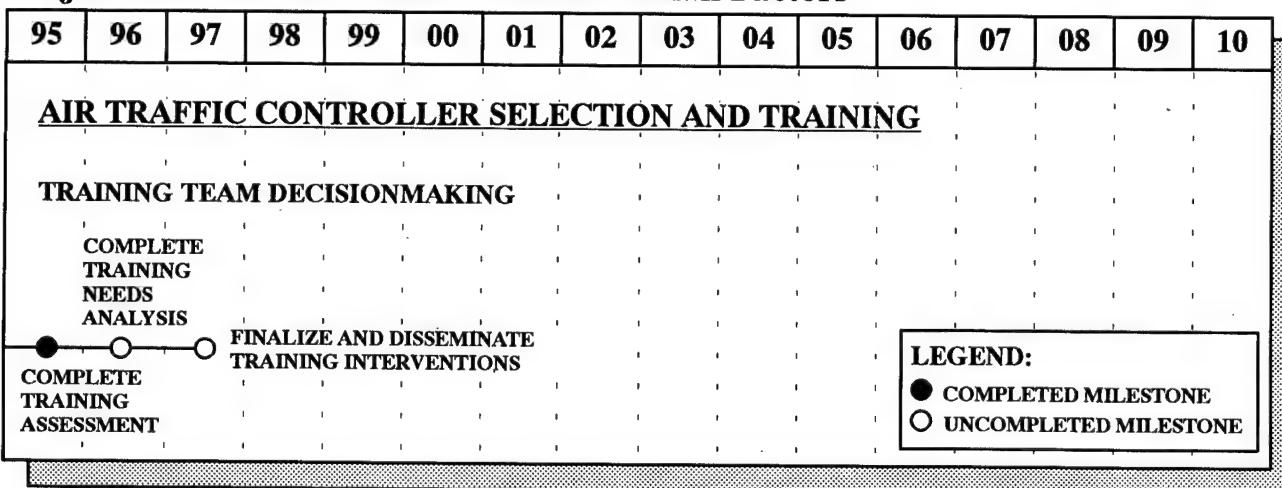
## Air Traffic Control Equipment/System Design

In 1998, research will be initiated to determine the most appropriate role for human operators in the ATC system of the future. From 1998 to 2003, human-in-the-loop analyses will be conducted for an ATC-specific environment. These research findings will be used with next-generation ATC automation system projections to develop an optimal human/computer concept by 2005. The premise for this concept will be to address automated equipment and human operators as integral parts of a whole system. Initial specifications based on the human/computer concept will be developed in 2006 for evaluation from 2006-2008. Final human factors design specifications for next-generation ATC automation systems will be developed by 2009.

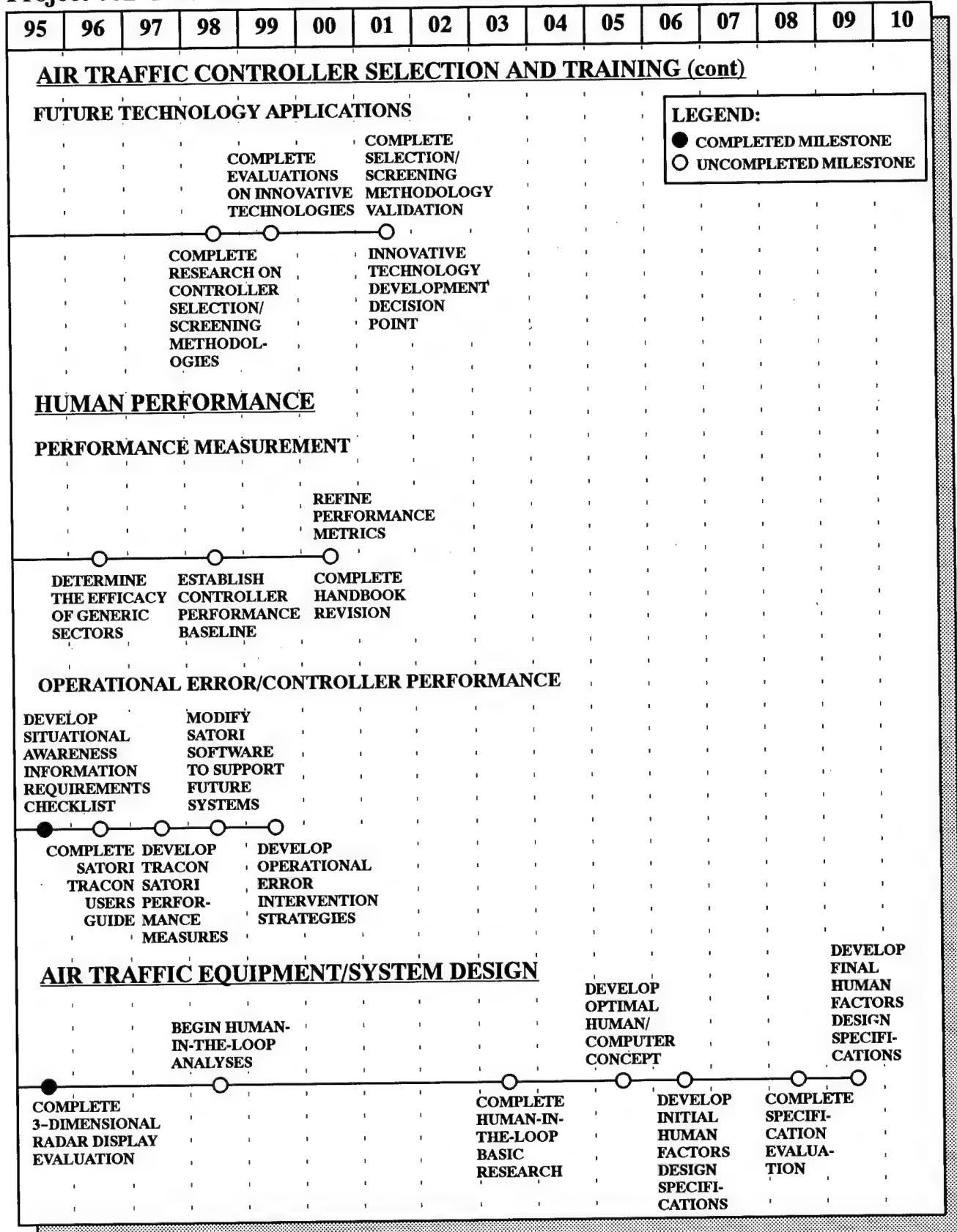
## Human-Centered Automation

In 1997, an assessment of the application of human factors design principles in the development and fielding of automated ATC systems will be completed. The resulting insights will be used to devise procedures and critical organizational structures that will facilitate the effective integration of human factors into the systems design and acquisition process.

## **Project 082-110: Air Traffic Control Human Factors**



## Project 082-110: Air Traffic Control Human Factors (continued)



## 083-110 Airway Facilities Human Factors

**P**urpose: The Airway Facilities (AF) organization has developed a strategic plan to manage change that is occurring as AF grows into a more service and systems management oriented organization. This plan addresses the vision of the Airway Facilities future organization and provides the outline for transitioning to this new operational concept. The AF Human Factors project provides the means by which enhanced human performance needs and user systems interfaces inherent in the functions identified in the strategic plan can be validated and alternatives for implementation can be addressed.

The purpose of this project is to optimize human systems in light of technological and organizational changes and to provide the necessary information for implementing the strategic plan. By conducting research in future workforce selection and training; organizational effectiveness; user-centered maintenance automation; and human performance, the AF Human Factors project will provide the input necessary to make informed decisions regarding the best methods to implement the strategic plan and achieve AF goals.

**Approach:** Task analyses will be conducted to provide the necessary data for developing knowledge, skills, abilities, position descriptions, and training criteria for current and future positions in automated systems. These analyses will also be used to develop computer/human interfaces (CHI) for new systems and determine where artificial intelligence and expert systems can best be incorporated into the maintenance environment. Simulations will be developed for different work environments to determine the impact of policy and/or procedural changes on workload and staffing. The evolving AF system specialist's role and workload in an automated system will be analyzed and appropriate interfaces developed to take advantage of advanced technology. Negati-

tive impacts of new systems being integrated into the NAS and into the AF operational culture and environment will be greatly reduced and result in a more satisfied, more productive workforce.

**Related Projects:** 082-110 Air Traffic Control Human Factors and 085-110 Aircraft Maintenance Human Factors. Capital Investment Plan project: M-07 National Infrastructure Management System (NIMS).

### Products:

- Human factors design guidelines for systems acquisitions
- Prototype Operations Control Centers (OCC's) situational awareness displays
- Error mitigation strategies for advanced AF maintenance control centers
- Symbology guidelines for future systems, including OCC's
- Prototype self-managed teams evaluations
- Organizational effectiveness pilot studies for maintenance functions, policies, and procedures leading to future system performance improvements

### 1996 Projected Accomplishments:

- Complete display symbology guidelines by adding auditory alarm and alerting guidelines to visual symbology guidelines.
- Complete current AF organizational effectiveness studies.
- Complete prototyping self-managed teams.

- Complete higher order AF task analyses for future systems applications and for training/selection requirements for AF personnel.

### Planned Activities:

#### Human Systems Optimization

In 1997, development work and evaluations of self-managed team prototypes which began in 1995 will be completed. Also in 1997, self-managed team implementation will begin along with a performance evaluation cycle that will be completed in 2001. Depending upon the performance evaluation results, self-managed team standards may be revised in 2003.

#### Advanced User Systems Interface

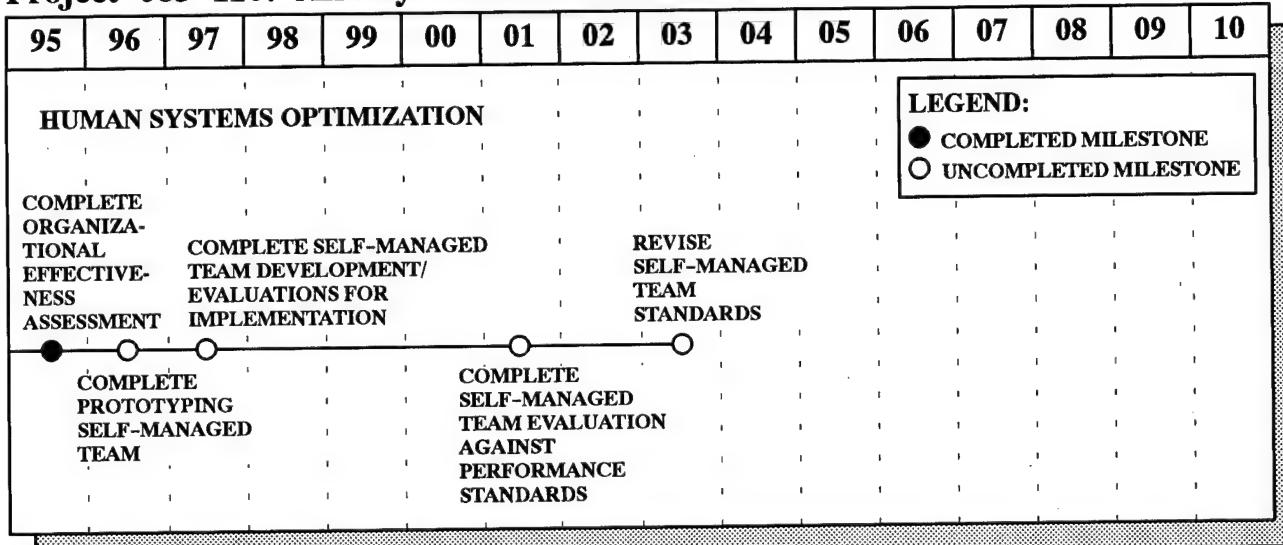
In 1997, scenarios for integrated system-level testing will be developed, and testing/evaluation will be initiated for linked personal computers and other expert systems. From 1998-2000, these scenarios will be used in an integrated testbed for simulating a hierarchy of subsystems such as automated diagnostics, predictive

weather systems, decision support systems, and workforce composition. By 1999, computer/human interface requirements will be completed for developing OCC/workstation performance specifications in 2000.

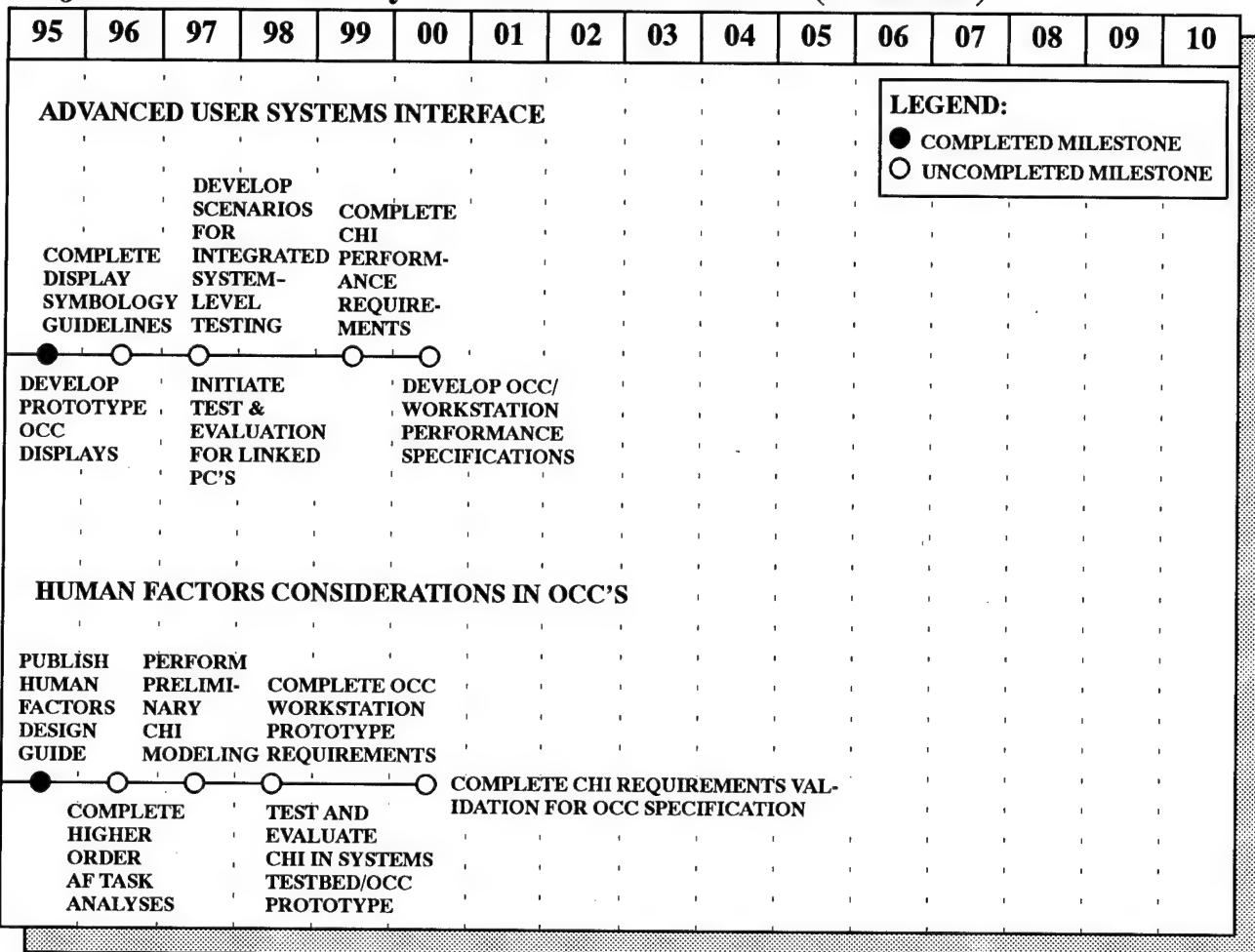
#### Human Factors Considerations in OCC's

In 1997, functional allocations and residual job task analyses will be completed. In 1997, the job task analyses data will be incorporated into preliminary computer/human interface models to examine their implications for information display and processing, job satisfaction under automated conditions, workload, and error mitigation. In 1998, these models will be used to complete the OCC workstation prototype requirements that will support OCC workstation prototype development. Also in 1998, the computer/human interface to the OCC workstation will be tested and evaluated in the AF systems testbed/OCC prototype developed by the Airway Facilities Future Technologies project. In 2000, the computer/human interface requirements will be validated and incorporated into the OCC specifications.

### Project 083-110: Airway Facilities Human Factors



## Project 083-110: Airway Facilities Human Factors (continued)



## 084-110 Flight Deck/ATC System Integration

**P**urpose: This project will ensure new-generation aircraft compatibility with the evolving automated NAS and decrease the frequency of flight deck/ATC communications errors through a total system approach. Flight deck/ATC integration raises unique considerations that are distinct from either ATC or flight deck issues and will be greatly affected by the technological improvements that are expected to occur simultaneously within both areas. Advanced computer aiding will facilitate controllers handling increased traffic but will also influence flight-

crew performance and situational awareness. Data link, and ultimately satellite-based air traffic systems, have the potential to enhance system capacity, but will also influence controller and pilot workload in ways that are not currently understood. The transition to a free flight concept of operations accelerates the need to effectively address these issues. NAS safety and efficiency will be enhanced through system-wide analyses that integrate current and emerging airborne and ground subsystems.

**Approach:** This project's objective is to enhance flight deck/ATC information transfer and management; decrease frequencies and consequences of flight deck/ATC errors; determine appropriate authority allocation between flight deck and ATC; and develop the required methods, tools, and guidelines for integrating NAS components into the flight deck/ATC environment.

The information transfer area will focus on identifying and resolving issues associated with transferring and managing information exchanged between the flight deck and ATC system. The areas to be studied include ATC clearances, traffic, weather, facility and equipment status, and related information. Both air-to-ground and ground-to-air information and data exchanges are of equal importance. The goal is to reduce information transfer errors and minimize their impact when they occur.

Verbal communications in ATC operations have been identified as causal factors in over 70 percent of operational errors and pilot deviations. Consequently, one of this project's major research areas focuses on developing means to decrease the frequencies/consequences resulting from pilot and controller communication errors. Efforts will focus on three areas: a pilot/controller communications analysis examining ATC voice tapes; analyses of aviation safety reporting system reports; and a series of laboratory experiments to assess the effectiveness of recommended changes in procedures and/or phraseology.

As intelligent automation applications increase on the ground as well as the flight deck, allocating authority between pilots and controllers becomes less well defined. This project will develop a decision support system to predict different authority allocations for various en route services. The decision support system will help the FAA make decisions on future pilot/controller selection, training, and operational authority allocation.

In cooperation with NASA, this program has jointly acquired and will operate a Boeing 747-400 research simulator with state-of-the-art avionics representing aircraft that will be predominant in airline fleets during the next decade. The simulator will be capable of stand-alone use, or can link via satellite to FAA ATC simulation facilities. Simulation studies involving this advanced technology cockpit will eventually be integrated into the National Simulation Capability. To operate a high-fidelity research simulator requires continued infrastructure investment, which this project will provide.

**Related Projects:** 025-110 National Simulation Capability (NSC), 031-110 Aeronautical Data Link Communications and Applications, 081-110 Flight Deck Human Factors, 082-110 Air Traffic Control Human Factors, and 086-110 Aeromedical Research.

#### **Products:**

- Human factors guidelines to establish policies for data link architectures and procedures
- Human factors guidelines for developing, testing, and certifying interface designs of various computer/human interface applications
- Operational and training recommendations to reduce pilot/controller verbal and digital communication errors
- Revised selection and training criteria for certification and regulatory personnel to properly match knowledge, skills, and abilities of pilots and controllers with changing performance requirements
- Capability to assess human performance in a highly integrated future automation environment

## **1996 Projected Accomplishments:**

- Conduct system integration experiments using the Boeing 747-400 simulator to support the National Plan for Civil Aviation Human Factors and the National Simulation Capability Operating Plan.
- Define critical elements of air and ground procedures at the free flight/controlled air-space boundary.
- Complete recommendations for graphical presentation of data link communications.
- Validate allocation strategies for distributing automation control decisions between flight deck and ATC.

**Planned Activities:** As new data link applications emerge, standards and certification guidelines, protocols, and procedures will continually be developed and/or revised. In 1997, research will be conducted on developing procedural and design solutions that reduce the likelihood or minimize the effect of previously identified communication errors. Through 1998, standards will be recommended for display content, format, menu design, message displacement, data link function control, and message alerting. In 1997, design and/or procedural solutions will be recommended to compensate for losing party line information if discrete data link replaces open frequency broadcasts. These solutions will ensure that flightcrews maintain situational awareness.

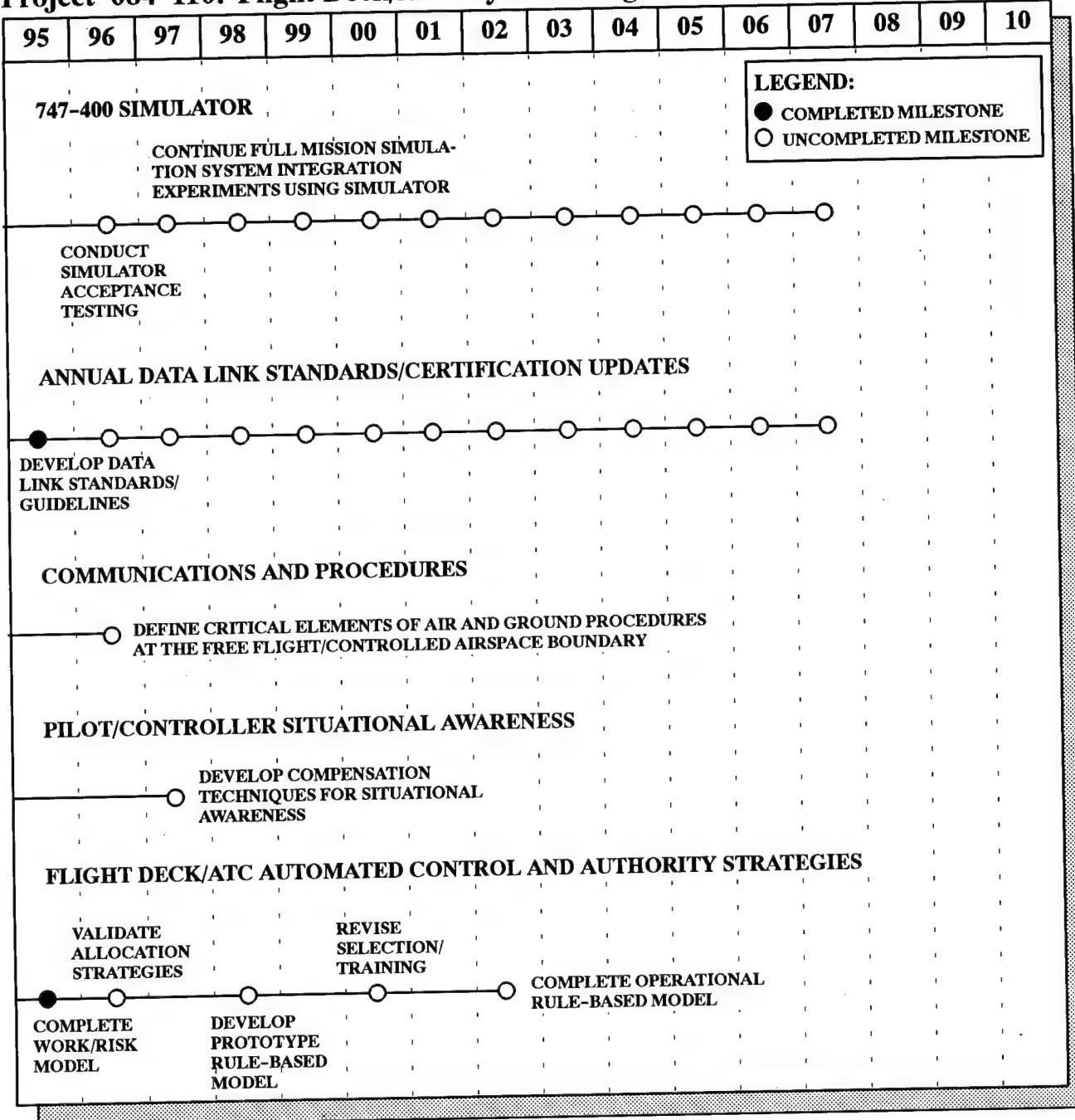
In 1997, research is expected to be completed on developing compensation techniques to ensure pilot/controller situational awareness when discrete digital communications are implemented. As automation and data link systems come on-line, techniques must be developed that provide the proper information at the appropriate time to keep human beings in the decisionmaking loop.

In 1997, research will continue on authority/responsibility allocations between pilots and controllers. One key research element will be developing a model that aids in predicting shifting authority allocations between the flight deck and ATC due to intelligent automation. Previously, allocation strategies were validated for distributing control decisions among the pilot, the controller, the airline dispatcher, and the NAS automation system. These validated strategies will lead to developing a prototype rule-based model in 1998 for use in various system design applications. This prototype will be transferred to the FAA Technical Center in 1999 for further developmental testing, with an operational model expected by 2002.

Revised selection and training criteria will be provided by 2000 to certification and regulatory personnel. These criteria will ensure that available skills are matched with the changing automation demands on pilots and controllers.

It is important to recognize that system integration research will never produce a definitive product that will close out this research domain; rather, it is a continual process that must be applied to every new generation of technologies as they emerge.

## Project 084-110: Flight Deck/ATC System Integration



## 085-110 Aircraft Maintenance Human Factors

**P**urpose: This project will develop and validate training methods to improve aircraft maintenance and inspection personnel perfor-

mance; develop regulatory support materials to revise Federal Aviation Regulation Parts 65 and 147; develop information on advanced

technology, techniques, and job performance aids for industry aircraft maintenance personnel and FAA Aviation Safety Inspectors (ASI); and develop information on how workplace environment and organization affect technician performance. A better understanding of these variables will lead to enhanced training methods, improved equipment human engineering, and improved FAA regulations/oversight. Accidents and incidents in air carrier operations attributable to maintenance and inspection human factors will be reduced as a result of this effort.

Research conducted in this area will ensure that future maintenance technicians will be optimally prepared for their roles. This research will develop guidelines and advisory materials for air carrier maintenance organizations concerning work environment factors that influence maintenance personnel performance. Also, information will be developed concerning the effects of advanced technology systems on FAA ASI performance.

**Approach:** This project addresses the following areas of the National Plan for Civil Aviation Human Factors: personnel and training systems, advanced technology systems, and environmental and organizational systems. It is important to remember that as new technology continues to enter the system, human factors research must be performed to ensure that the human/machine interface is optimized. This research will continue into new areas as technology evolves.

This project will conduct research on visual and nondestructive inspection (NDI) techniques. Laboratory and field research studies will be conducted to determine factors that influence air carrier inspection specialists' performance. Advisory guidance material based on this information will be supplied to air carrier maintenance managers for training, planning, and work assignment purposes.

A major element in this project is researching information needs for FAA field inspectors. The

intent is to examine existing processes and develop improved methods for ASI's to access needed information and provide input to national data bases. ASI's have frequent need to access information such as advisory circulars, airworthiness directives, and regulations. Inspectors also need to provide the results of their inspections so that information is quickly accessible to data base users. Various computer-based technologies will be explored to determine their utility in optimizing inspector performance.

Work environment research has developed knowledge of visual, auditory, thermal, and biomechanical requirements or limitations concerning skilled psychomotor activity in general. Subsequent work will evaluate the application of this knowledge to specific aircraft maintenance operational settings. Organizational/managerial research will examine the influence of management practices, expectations, and norms as well as personnel practices, team operations, and organizational structure on maintenance performance.

**Related Projects:** 065-110 Aging Aircraft.

#### **Products:**

- Job task and training analyses
- Human factors and ergonomics audit program in maintenance shops
- Human factors guidelines to reduce automation-related errors in maintenance for government and industry
- Intelligent tutoring systems
- Supporting data for FAR Parts 65 and 147 revisions
- Human factors guidelines for industry/government communication, data exchange, and support infrastructure

- Advanced documentation technology to provide rapid access to technical information

#### 1996 Projected Accomplishments:

- Develop concept guidelines on maintenance technician resource management.
- Support Sandia Laboratories visual inspection using previously developed visual inspection and NDI guidelines.
- Develop and evaluate work environment influence on technician performance.
- Implement and evaluate human factors and ergonomics program in maintenance shops.
- Evaluate situational awareness related to maintenance environments.
- Update Human Factors Guide.
- Complete aviation safety inspector job aid tool.

- Develop electronic version of human factors issues guidebook.

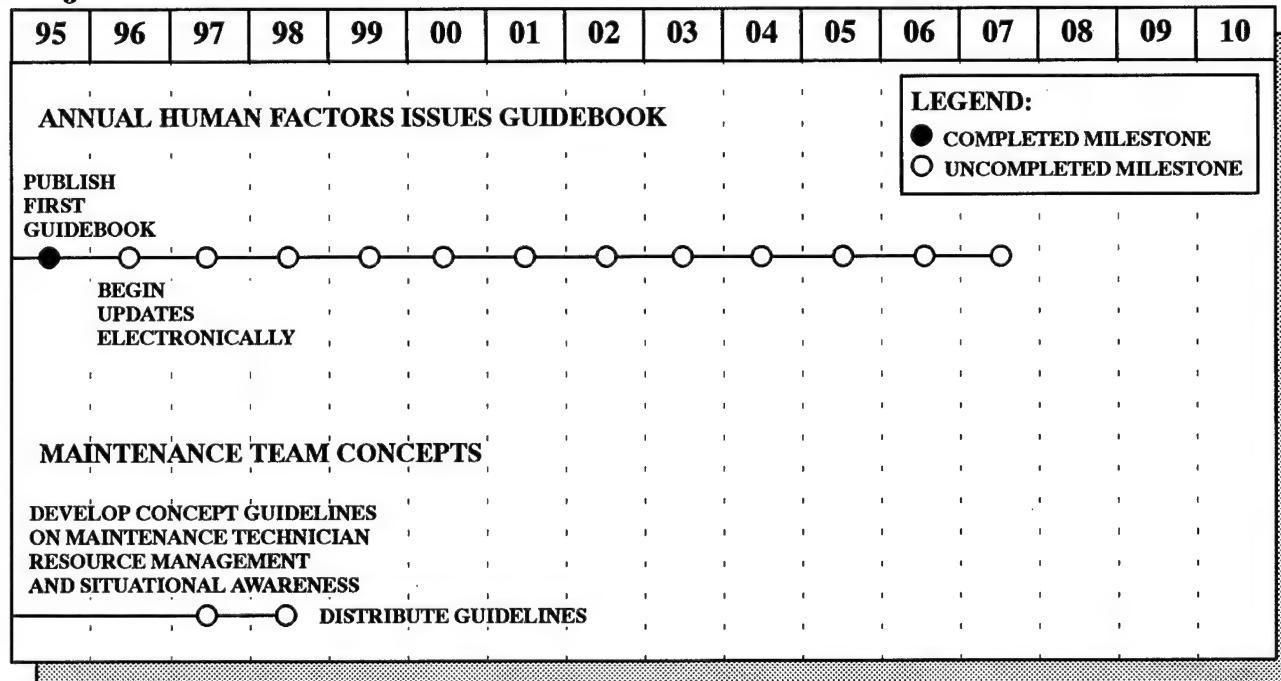
**Planned Activities:** In 1997–1998, updates will be published to the human factors issues guidebook. These updates will be published annually in an electronic format.

In 1997–1998, guidelines will continue to be developed and evaluated on technician resource management and situational awareness. Results from these guidelines will be made available to regulatory organizations and industry by 1998.

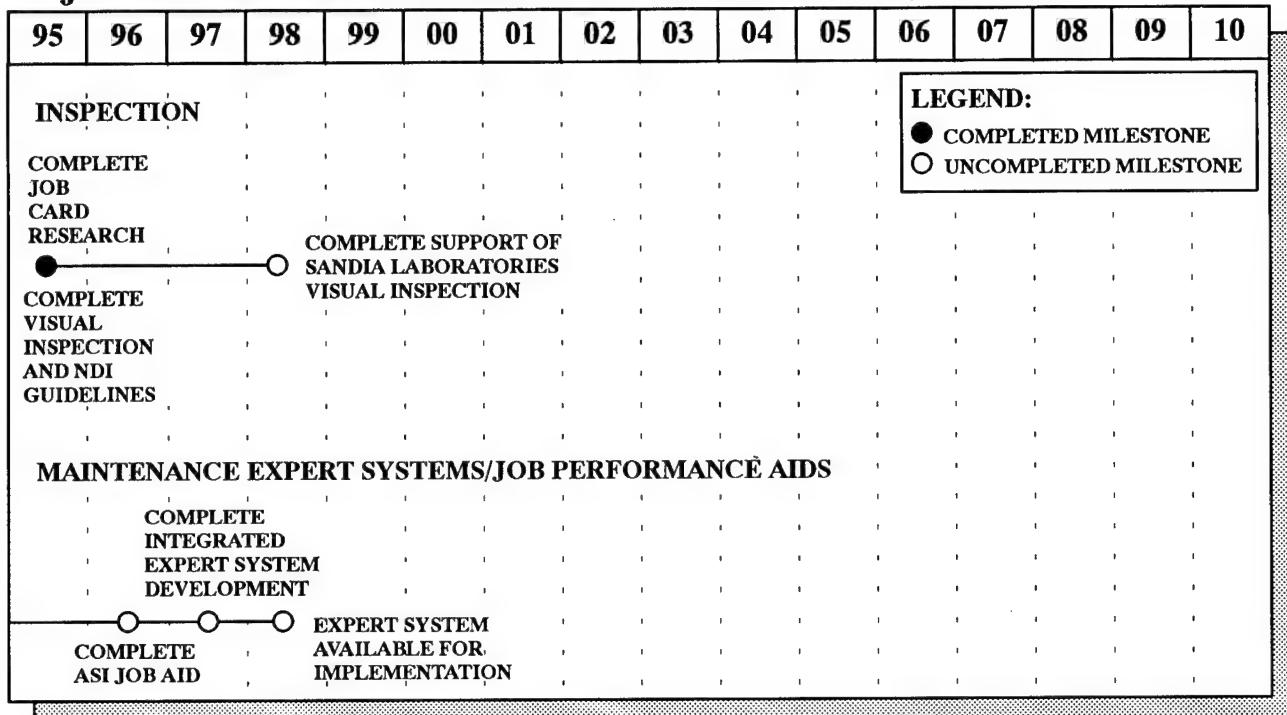
In 1997–1998, previously completed techniques on visual inspection and NDI will continue to undergo testing at Sandia Laboratories to support the aging aircraft program.

In 1997, an expert system will be developed for integrated training/job aiding/information retrieval. Voice recognition, a key human/ system component, will be evaluated. In 1998, the complete system will be available for implementation.

#### Project 085-110: Aircraft Maintenance Human Factors



## Project 085-110: Aircraft Maintenance Human Factors (continued)



## 086-110 Aeromedical Research

**Purpose:** This project will assess types of injury and death patterns in civilian flight environments, recommend and develop protective equipment or procedures, and provide guidance to FAA regulatory and medical certification staff. The component tasks of this research will identify human physiological and bioengineering failure modes in both uneventful flight and during civil aircraft incidents/accidents, while simultaneously assessing counteracting measures. The research will also identify pilot and passenger medical conditions that are incompatible with civilian flight demands. This detailed information will be used to determine if existing equipment and procedures optimally protect the human occupant; to make technical recommendations contributing to improved performance standards; and to support bioengineering, biochemistry, and biomedical aspects of certification actions and rulemaking. Prioritizing

subtasks is directly responsive to the Aircraft Certification Service, the Office of Accident Investigation, the Office of Aviation Medicine, and also to unique injury and death characteristics in contemporary accidents. This prioritization allows the FAA and the National Transportation Safety Board to effect expeditious corrections of unsafe and dangerous conditions.

**Approach:** Tasks in this research area are derived from requirements generated within the FAA by the Aircraft Certification Service, the Flight Standards Service, the Northwest Mountain Region Transport Airplane Directorate, the Southwest Region Rotorcraft Directorate, the Central Region Small Airplane Directorate, and the Offices of Aviation Medicine and Accident Investigation. Organizations outside the FAA generating requirements through FAA channels include the National Transportation Safety

Board, the military services, and the Society of Aerospace Engineers. All project activities are coordinated with government agencies and industrial representatives having related technical interests. The FAA research process ensures project coordination among the FAA performing organizations, such as the Civil Aeromedical Institute and the Technical Center.

This project broadly encompasses laboratory and field studies on the performance of the cabin crew, medically certified airmen, and aircraft passengers. Furthermore, equipment and procedures approved by the FAA and designed to protect personnel in accident situations are evaluated. The studies include evaluating injury mechanisms that might result from system failures or from hazardous conditions such as smoke or toxic gas environments. The studies support rulemaking or certification actions by developing performance standards and evaluating the merits, deficiencies, costs, and benefits of specific safety-related procedures and appliances. The same research generates educational spinoffs that, in cooperation with industry and airspace users, guide the aviation participant in the optimal use of safety equipment or procedures.

This project consists of three research initiatives: human protection and survival; medical and toxicological factors of accident investigation; and Federal Air Surgeon program support. Protecting humans in decelerative environments, protective breathing equipment, cabin evacuation, and water survival are currently being investigated in the human protection and survival initiative. Toxicological assessment and sudden or subtle pilot incapacitation are key features of the medical and toxicological factors of the accident investigation initiative. New vision corrective methods for aviation personnel, radiation hazards, and air ambulance medical requirements represent current clinical investigations under the Federal Air Surgeon program support initiative.

**Related Projects:** 061-110 Fire Research and Safety, 062-110 Advanced Materials/Structural

Safety, 081-110 Flight Deck Human Factors, 082-110 Air Traffic Control Human Factors, and 084-110 Flight Deck/ATC System Integration. Capital Investment Plan projects: F-19 Aeronautical Center Leases, F-18 Aeronautical Center NAS Support Facilities, and M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

### **Products:**

- Quantitative bioengineering criteria to support aircraft seat and restraint system certification
- Quantitative biomedical criteria to support protective breathing equipment and operational procedures certification
- Quantitative biochemical and toxicological criteria supporting the use or certification of aircraft interior fire, smoke, and toxicity limits
- Quantitative biomedical criteria to support flotation and onboard rescue equipment certification
- Revised aircrew medical criteria, standards, and assessment procedures
- Identifying medical causative factors in aviation incidents and accidents
- Occupational health assessments for unique populations in the aviation community

### **1996 Projected Accomplishments:**

- Develop new techniques to reduce injuries to children in aircraft crashes.
- Develop improved side-facing seat technology.
- Adapt state-of-the-art anthropometric test dummies for aircraft crash assessments.

- Develop recommendations for standardizing supplemental oxygen use at lower altitudes.
- Develop aircraft cabin evacuation approval guidelines that optimize human factors considerations.
- Complete initial aircraft cabin air quality assessments in cooperation with the National Institute of Occupational Safety and Health.
- Develop guidelines for certification of photorefractive keratectomy in civil aviation pilots.
- Develop guidelines to reduce inflight sudden/subtle incapacitation.

#### **Planned Activities:**

##### Human Protection and Survival

In 1997, data will be developed to assess the patterns of lower extremity injuries in "16-G" seats. Also, research on cervical spine injury detection and prevention will be continued. This data will assist the FAA in developing new certification criteria based on technology improvements. A key emphasis will be on conducting long-term research to improve high altitude breathing equipment biomedical standards by 1997. A prototype improved general aviation oxygen mask will also be developed by 1997, with an operational model available in 1999.

In 1997, work will continue on emergency medical equipment in air carriers, permitting a regulatory review. This review will support specific research in advanced medical capabilities such as automatic defibrillators and state-of-the-art medications in air carriers. Air ambulance medical equipment and crashworthiness requirements will continue to be evaluated during 1997, permitting the development of consensus guidelines. Further analyses on crashworthiness and electromagnetic interference will continue through

2002. Annual recommendations will be provided to the Aircraft Certification Service and the Office of Aviation Medicine for developing standards.

The dual aisle aircraft cabin evacuation research capability (747 fuselage) will be brought on line in 1997 to permit the development of safer evacuation certification procedures, as well as more effective field emergency evacuations of aircraft. The associated research will contribute to certification guideline development targeted for 1999. Concurrent single aisle cabin evacuation research will continue to provide data on slide versus platform evacuations as alternative FAA certification approaches. Additional research flexibility using an enclosed flexible simulator permitting quick reconstruction of various seating, aisle, and exit geometries is planned for 1998. In parallel, development will begin in 1997 on a dual aisle emergency evacuation model, with first prototype expected in 2000 for possible implementation in 2002. Between 1998-2009, evacuation models will be developed for future aircraft, such as the high-speed civil transport and 800-plus passenger aircraft, that are iterations of the dual and single aisle models.

##### Medical and Toxicological Factors of Accident Investigation

In 1997, laboratory and field clinical research to determine causative human factor elements in aircraft accidents will continue. The FAA Office of Accident Investigation continually requires this data to complete its investigations of complex and diverse aircraft accidents.

In 1997, a tool will be developed to permit toxicologists to determine whether alcohol detected in accident victims was ingested or was generated postmortem. This data will clarify medical and legal uncertainties surrounding an accident's cause. The multi-year analyses of benzodiazepines and antihistamines as factors in accident causation will be published in 1997. Long-term

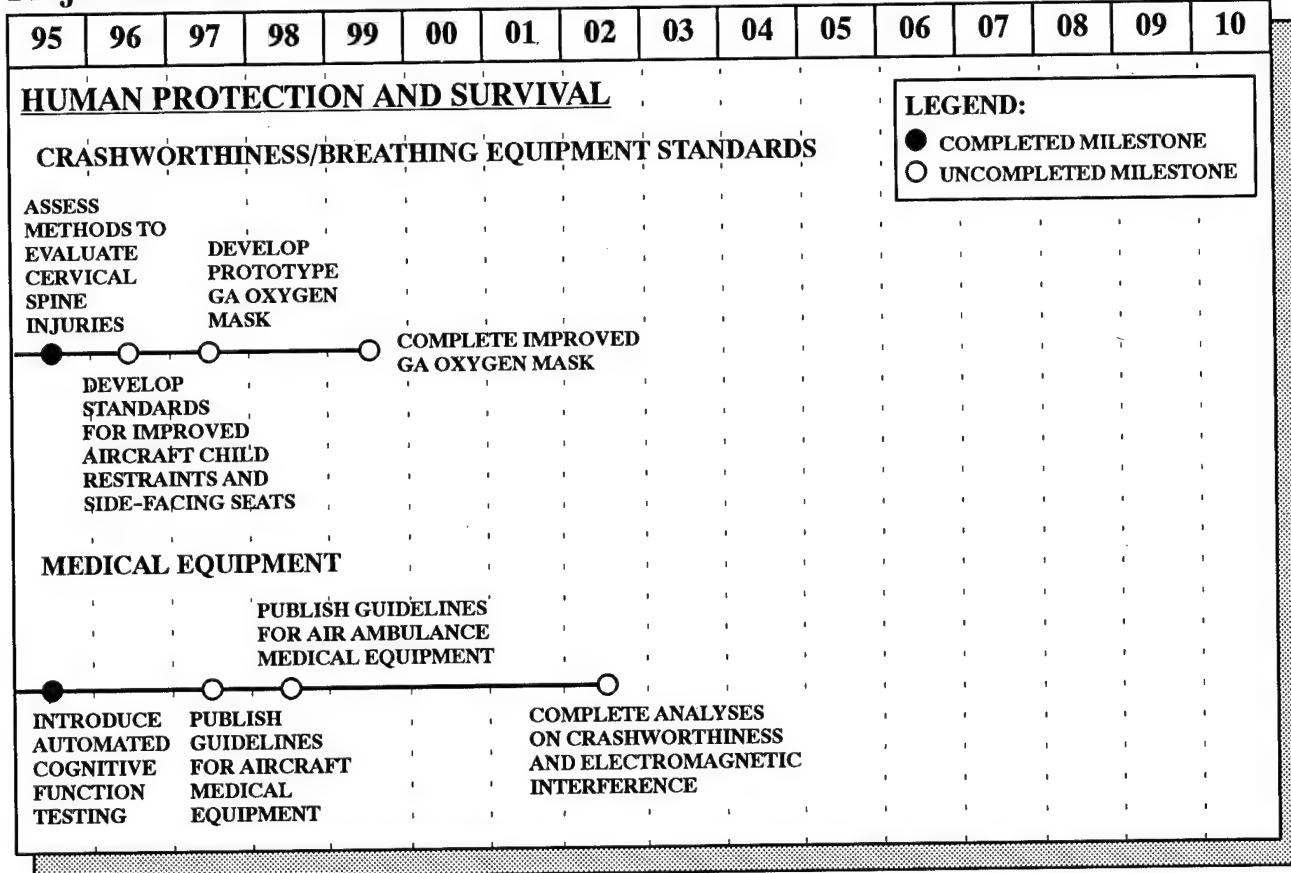
research is targeted at developing updated guidance for using over-the-counter and prescription medications by civil aviation pilots in 1998.

#### Federal Air Surgeon Program Support

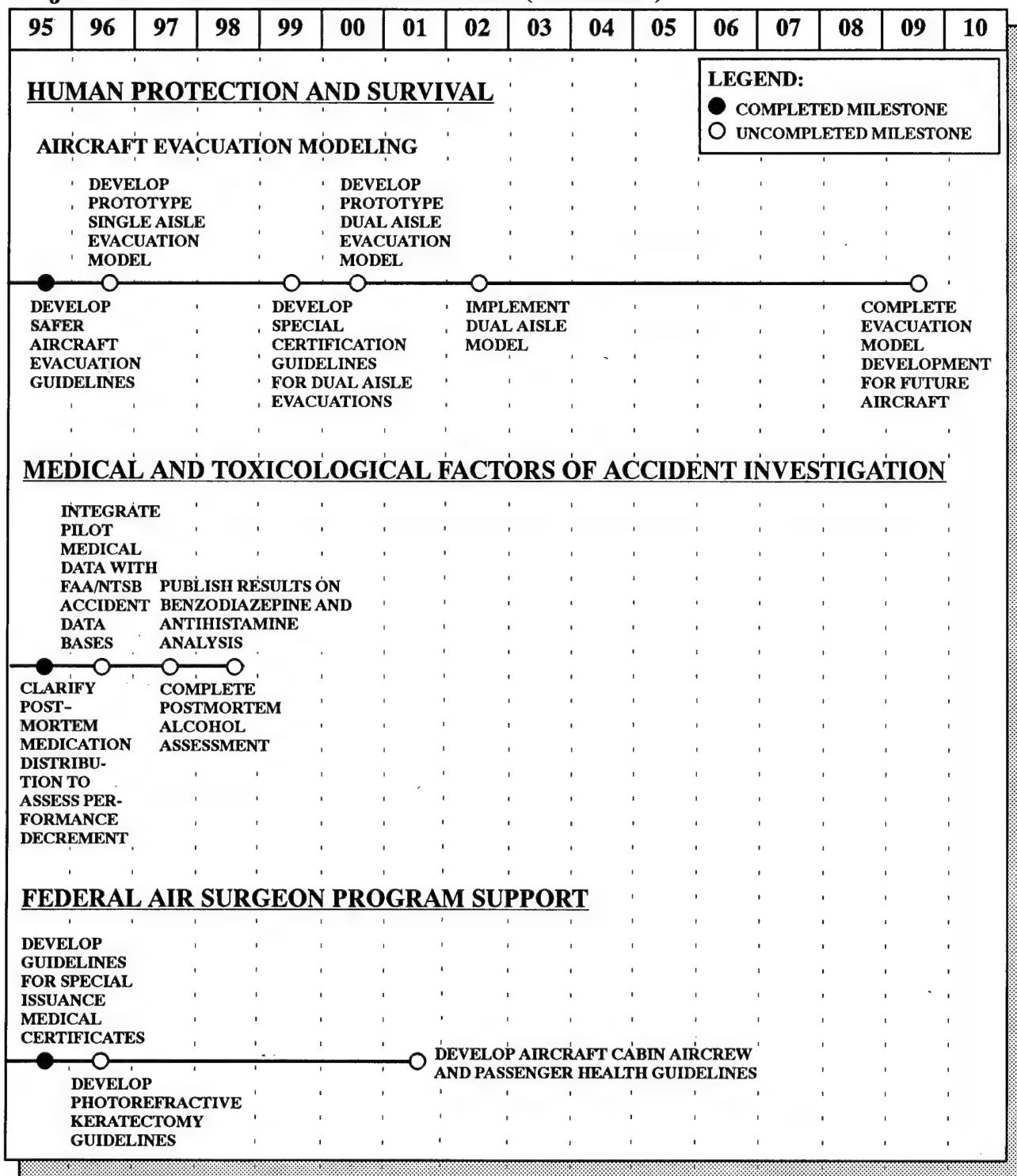
By 2001, joint FAA/National Institutes of Occupational Safety and Health research into cabin crew occupational health will determine the need for new guidelines to protect aircrew and passengers.

Other long-term research to support the FAA's mission necessitates ad hoc studies on seat and restraint systems; optimizing aircraft exit configurations; maintaining cabin safety and anthropometry databanks; assessing human factors in aircraft accident causation; performing toxicity studies; profiling chemical abuse in aviation; examining effects of drugs and physiological stressors on performance; evaluating new vision corrective devices; and testing medical equipment in civilian aircraft.

#### **Project 086-110: Aeromedical Research**



## Project 086-110: Aeromedical Research (continued)



## 9.0 ENVIRONMENT AND ENERGY

Research, Engineering and Development (R,E&D) projects in this thrust area support national goals to protect the environment, conserve energy, and keep the U.S. air transportation industry strong and competitive. In 1995, approximately 1.7 million individuals lived within areas considered to be exposed to significant airplane noise (a day-night average sound level of 65 decibels or more) and more than 400 U.S. airports have adopted some type of airport restriction to reduce aircraft noise or mitigate its effects. In some cases these restrictions have little impact on airport capacity, but in others the potential airport capacity has been reduced by as much as 30 percent. While there is an effort underway to ensure an early phaseout of older, noisier aircraft, there will clearly be a demand for even more stringent limitations on aircraft noise. Air pollution from aircraft is also becoming a major concern in airport expansion and proposed new airport construction. New aircraft and new aircraft engine types offer potential relief to the public; however, substantial R,E&D will be required to support future regulations.

The future aviation system will be one that is a "good neighbor" to the people living near airports. The challenges revolve around issues associated with how this good neighbor policy is implemented. While noise and pollution are the primary challenges, other issues associated with the atmospheric effects from new aircraft types, and new or alternative fuels, will require analysis and investigation.

The value gained from projects in this thrust area will derive from reducing both direct and indirect costs associated with meeting the national goals. Discovering ways to build quieter engines that have fewer noxious emissions is the direct

approach. The indirect approach is to develop ways to use existing equipment more appropriately. Both approaches are reflected in this thrust area's projects.

A benefits assessment associated with these projects is underway. Noise reduction assessment strategies will be built around meeting local noise restrictions in ways that have less impact on airport capacity and, therefore, on system delays.

The FAA's policy for environment and energy issues is to provide strong leadership in mitigating aviation's adverse impact on the public, consistent with sound energy planning and an effective aviation system. The FAA has adopted the following strategies:

- Lead a cooperative development effort that balances noise reduction with adequate airport capacity.
- Manage FAA activities to minimize adverse environmental consequences and comply with all federal statutes.
- Develop sound aviation energy plans.
- Stimulate private industry and government-sponsored research to reduce noise, emissions, and energy consumption by the aviation sector.

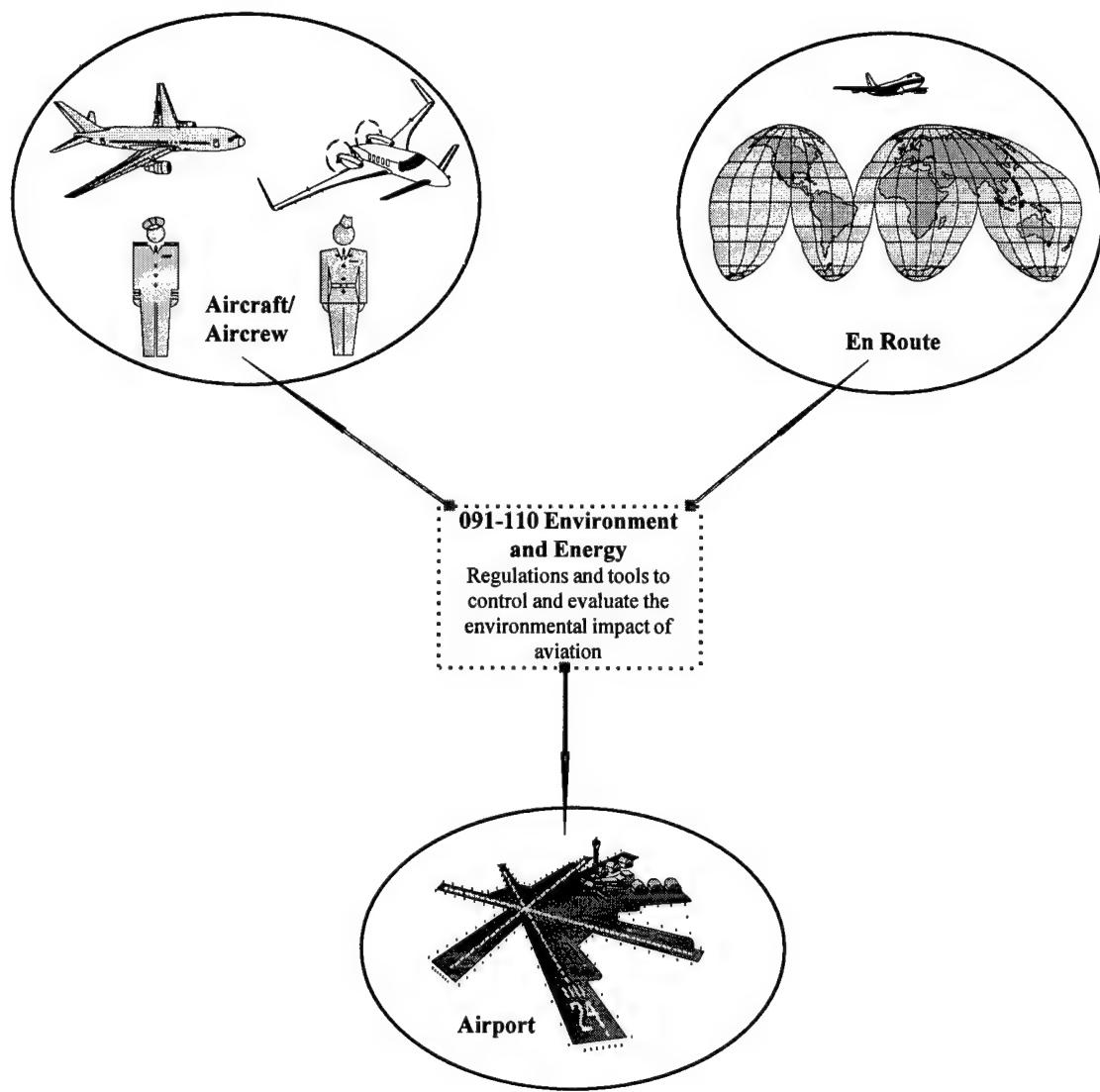
The Research, Engineering and Development Plan for the Environment and Energy thrust area responds directly to these strategies, and to the recently passed Airport and Airway Safety, Capacity, Noise Improvement, and Intermodal Transportation Act of 1992, and the Clean Air Act Amendments of 1990.

Through joint efforts with industry, the FAA will improve regulatory standards for noise and air pollution. It will also develop better technologies for predicting, measuring, and abating the environmental impact from aircraft emissions.

Research will help define global standards for noise and air quality that are now being developed by the International Civil Aviation Organization.

## Environment and Energy Project

### Contributions to FAA Services



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## 9.1 Environment and Energy Project Descriptions

### 091-110 Environment and Energy

**P**urpose: This research supports the FAA Strategic Plan to provide strong leadership in mitigating the adverse environmental impacts of aviation. This project will develop various tools and methods used to evaluate the environmental impact from alternative aviation policies and strategies. The focus will be on controlling both aviation noise, a major constraint on airway and airport capacity, and aircraft exhaust emissions in the upper atmosphere, a growing public concern. The project will also ensure FAA compliance with all federal environmental statutes, such as the Airport and Airway Safety, Capacity, Noise Improvement, and Intermodal Transportation Act of 1992 and the Clean Air Act Amendments of 1990.

**Approach:** Environment and Energy R,E&D consists of the following major disciplines: aviation environmental analysis; aircraft noise reduction and control; aircraft engine emissions reduction and control; and FAA energy conservation.

#### Aviation Environmental Analysis

The aviation environmental analysis and the aircraft noise reduction and control activities will eliminate many constraints on aviation growth, especially on airport capacity, through technology and expertise aimed at mitigating or controlling aircraft noise. These activities will include continually updating and improving the integrated noise model, the heliport noise model, the area equivalent method, and the nationwide airport noise impact model. These noise models are used to predict and assess the impact from FAA policies and federal actions. Research will be conducted to develop better tools for assessing the costs and benefits associated with noise reduction and control activities.

A cooperative research program with the National Aeronautics and Space Administration (NASA) will investigate human response to noise levels as part of a longer range program aimed at developing a better understanding of community reaction to aircraft noise exposure.

#### Aircraft Noise Reduction and Control

The FAA has entered into a joint research program with NASA research centers to investigate technology advances in source noise reduction. The research will include engine design parameters, advanced acoustic absorption materials, and active noise control devices. Aircraft technology advances will include high lift devices and methods to reduce airframe-generated noise.

Noise testing will be conducted to simplify existing certification procedures and develop new procedures for future aircraft. Noise requirements for heavy helicopters, advanced subsonic transports, high-speed civil aircraft, and hypersonic research vehicles will be evaluated in cooperation with industry.

#### Aircraft Engine Emissions Control

The FAA will undertake a joint high altitude pollution research program with NASA's research centers to investigate new technologies in jet engine combustor designs that reduce engine emissions, specifically nitrogen oxide emissions. These emissions generate particular concern due to their potential impact on the upper atmosphere. The results from these investigations will be used in developing future engine emission regulations and international standards. Studies with NASA will also investigate both current subsonic and high-speed civil transport's (HSCT) effect on the ozone layer and global

climate change. These studies are intended to determine the HSCT's future viability and the need for aircraft engine emission standards at cruise altitude conditions.

#### Energy Conservation and Aviation Energy Emergency Contingency Planning

This project will support achieving a 30 percent energy use reduction or a 30 percent increase in efficiency in FAA buildings by 2005 as compared to 1985. It seeks to minimize energy use in federal facilities to comply with Executive Order 12759. The FAA also will review and evaluate the present energy management reporting system. Based on this review, the system will be upgraded and enhanced, or replaced with another tracking and reporting system. A user training program will also be developed. The reporting requirement is mandated by Executive Order 12759 and the National Energy Conservation Policy Act, as amended.

**Related Projects:** 022-140 General Aviation and Vertical Flight Program, 024-110 Aviation System Capacity Planning, and 025-130 Air Traffic Models and Evaluation Tools. Capital Investment Plan projects: M-03 Capital Investment Plan (CIP) System Engineering and Technical Assistance.

#### **Products:**

- Mathematical models to compute the impact from aviation noise for both airports and heliports
- Mathematical models to compute aviation contributions to airport and upper atmospheric air pollution
- New, simplified, aircraft certification procedures for contemporary airplanes and helicopters

- Handbooks and guidance material for FAA field personnel involved in aircraft certification
- Certification standards for new technology aircraft including ultra high-bypass engines and HSCT's
- Studies to identify feasible technologies leading to potential noise certification standards

#### **1996 Accomplishments:**

- Develop noise impact routing computer model for assessment of airspace design.
- Publish report assessing noise reduction technologies for propeller-driven airplanes and rotorcraft.
- Publish handbook on engine exhaust emissions certification procedures.

#### **Planned Activities:**

##### Aviation Environmental Analysis

The system of airport noise analyses and impact assessment tools and processes will be expanded in 1998 to include major air traffic management and airspace improvement projects. Also, vertical flight noise assessment tools will be completed for use in heliport/vertiport development. Additionally, research will begin on developing a non-airport noise assessment prediction capability. A prototype noise assessment tool will be developed in 2000 for field validation in 2002, followed by distribution in 2003

##### Aircraft Noise Reduction and Control

In 1997, simplified noise certification procedures will be developed for large helicopters. From 1997-2000, the FAA/NASA research effort

assessing subsonic jet noise reduction technologies will continue. Annual reports will be published to describe results, track project progress, and identify promising technologies. In 2000, the research will identify economically feasible technologies for U.S. manufacturers to develop quieter airplanes.

From 1997 and continuing through 2003, an FAA/NASA research effort will assess rotorcraft noise reduction technologies. Annual reports will be published to describe research results, track project progress, and identify promising technologies. In 2003, research will identify economically feasible technologies for U.S. manufacturers to develop quieter helicopters.

Starting in 1997 and continuing through 2001, an FAA/NASA research effort will identify promising noise abatement technologies for propeller-driven airplanes.

#### Aircraft Engine Emissions and Control

To ensure consistency with known changes in the Clean Air Act, the FAA will update the Federal

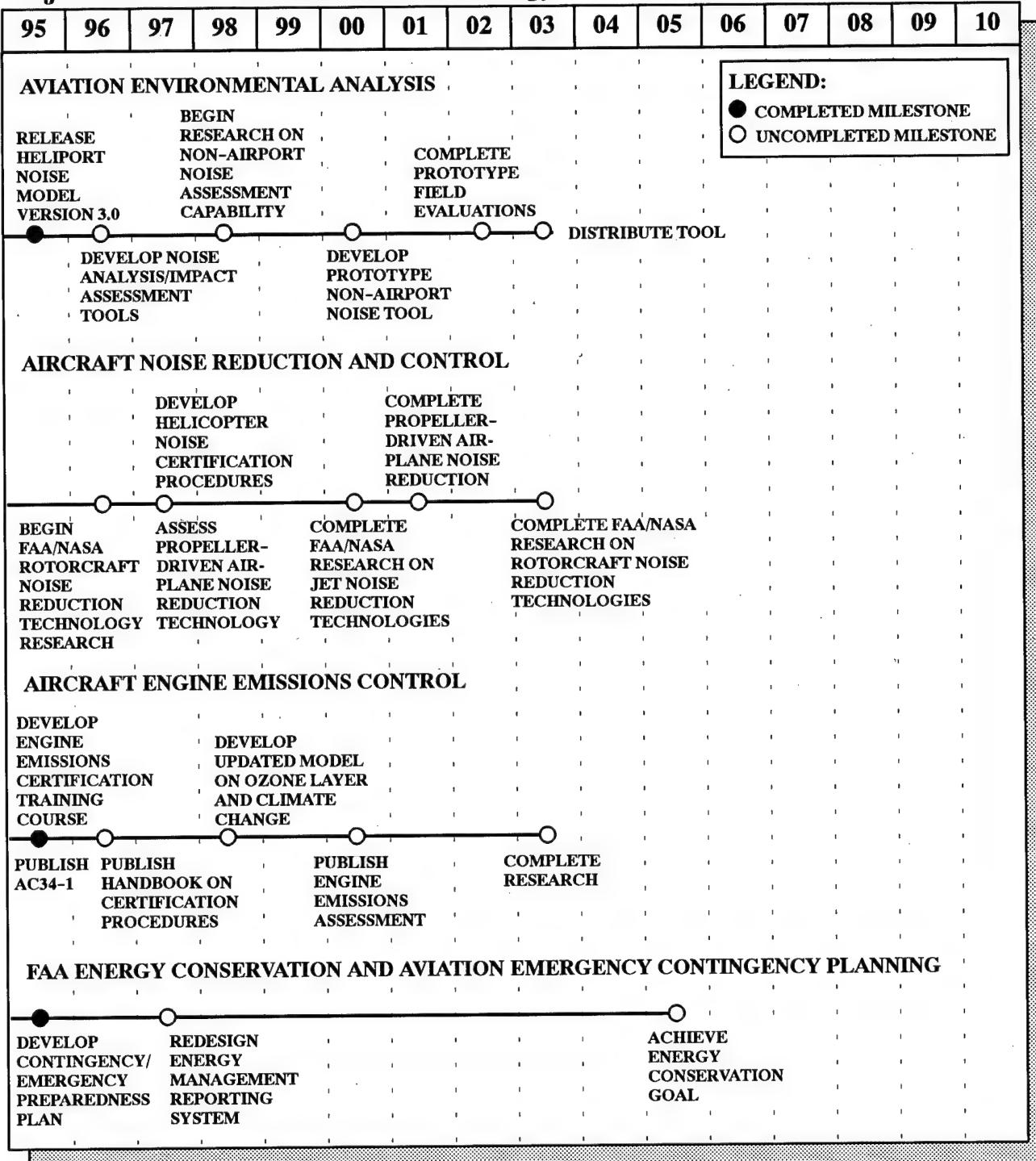
Aviation Regulations on aircraft emissions in 1998. The FAA's data base on emissions characteristics will be expanded by collecting data on new technology and newly certified engines.

In 1998, an updated version of the global aircraft emissions forecasting model will be developed to predict the atmospheric effects from subsonic and HSCT emissions on the ozone layer and global climate change. An assessment will be published in 2000 with research continuing through 2003 to develop new engine emissions technologies. The final product will be using these analyses and research efforts to develop engine emissions certification standards and other regulatory actions.

#### Energy Conservation and Aviation Emergency Contingency Planning

In 1998, a redesigned energy management reporting system will be distributed in the field for the assessment of the agency's energy and water conservation measures.

# Project 091-110: Environment and Energy



## LEGEND:

- COMPLETED MILESTONE
- UNCOMPLETED MILESTONE

## APPENDIX A

### **Innovative/Cooperative Research**

The Innovative and Cooperative Research program provides for research, engineering, and development (R,E&D) partnerships with industry, academia, and other government agencies as a means for leveraging FAA R,E&D investments with complementary investments from these other sectors. In 1995, it is estimated that industry will invest approximately \$25 million in R,E&D partnerships with FAA. An additional investment of \$30 million will be made in dollars and in-kind through partnership agreements with academic institutions. Similar levels of investment are expected in 1996.

The R,E&D products developed through these partnerships are essential for the safe, efficient, and cost-effective operation of the air transportation system in the U.S. Products developed in the recent past include:

- A crushable pavement for runway ends to safely arrest overrunning aircraft.
- A device for screening bottled products in passenger carry-on baggage to assure that the bottles do not contain explosives.

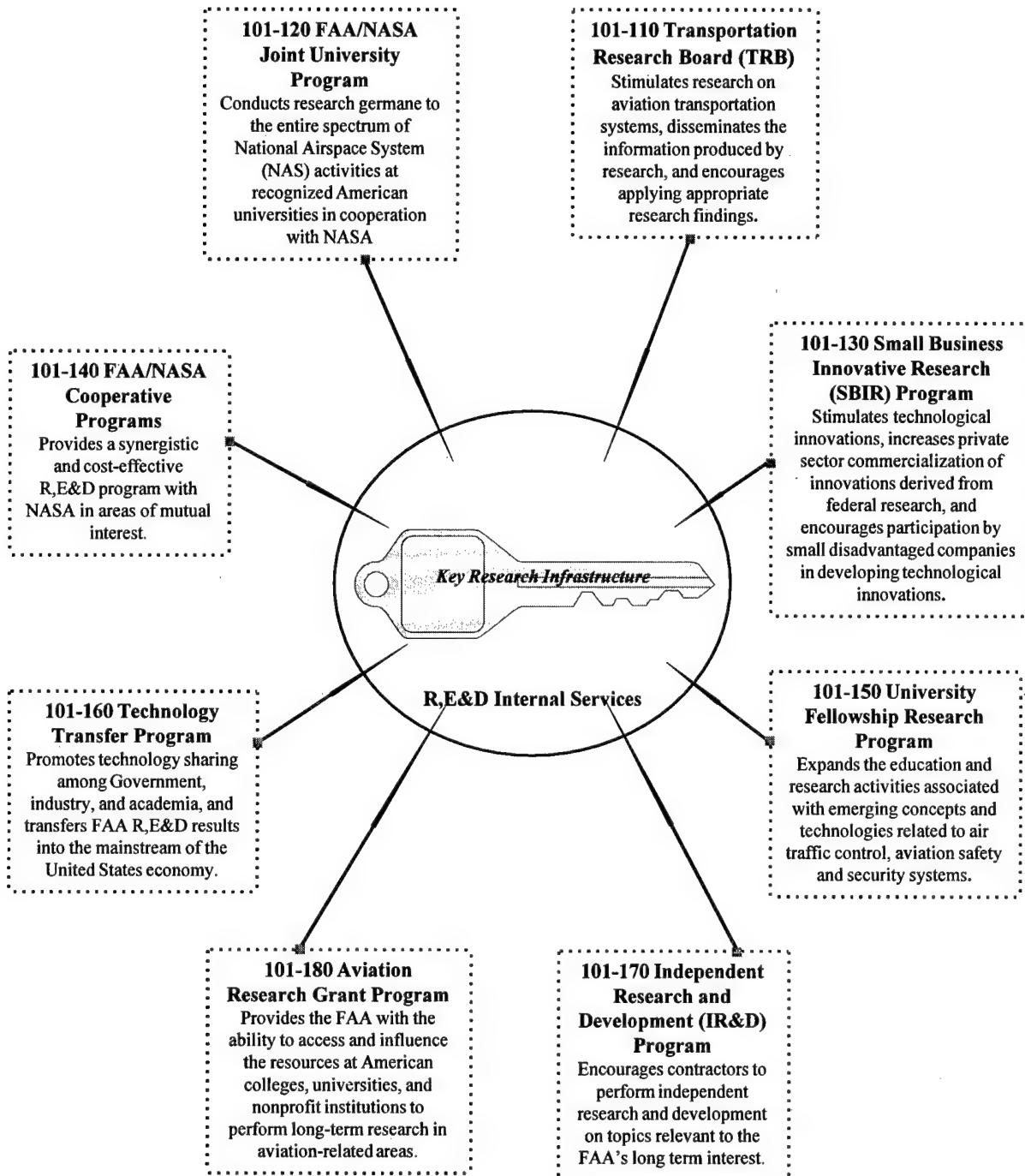
- A capability based on the global positioning system to safely land aircraft in inclement weather conditions.
- A multifunction terminal area radar capability that can detect and track both aircraft and weather systems.

The program area also makes essential contributions to the quality of the FAA R,E&D program by:

- Providing a ready means for industry to contribute R,E&D solutions through cooperative research agreements and Small Business Innovation Research contracts.
- Fostering the insertion of innovative new technologies and concepts through partnerships with academia and industry.
- Assuring a continued supply of young scientists and engineers interested in aviation research and able to contribute.

## Innovative/Cooperative Research

### Contributions to FAA Services



## **101-110 Transportation Research Board (TRB)**

**P**urpose: This program stimulates research concerning the nature and performance of aviation transportation systems, disseminates the information produced by the research, and encourages applying appropriate research findings. This research influences the FAA's future policy direction. The TRB is a National Research Council unit that serves the National Academies of Sciences and Engineering. The products from this research help the public sector focus on technical and management innovations developed by the academic and private sectors to resolve current and future critical issues. The TRB also provides an independent perspective on means that could be used to improve safety, manage the national aviation system, increase capacity and productivity, and stimulate interest in highly qualified students to pursue careers in aviation.

**Approach:** The FAA determines specific research to be conducted and awards research

contracts to the TRB. This program is carried out largely by committees, task forces, and a panel staffed by industry, public officials, and university experts who serve without compensation. The FAA provides one or more analysts to participate on these committees, task forces, and panels. The Board's efforts also include research on aviation's future by conducting an annual Graduate Research Award Program. This program focuses on technical and management innovations for civil aviation facilities in the next century and other special research projects to further the national aviation system's safety and efficiency. Completed products are normally transmitted to the FAA, industry, and general public as an official TRB circular. The Graduate Research Award Program papers are also presented at a special session of the annual TRB meeting.

## **101-120 FAA/NASA Joint University Program**

**P**urpose: This program conducts research germane to the entire spectrum of National Airspace System (NAS) activities at recognized American universities in cooperation with NASA. It also assists in educating professional personnel needed to develop and manage the future NAS components. Solutions to large scale systems problems related to the national air transportation system ultimately come only after the technological foundations have been laid through basic research. The Joint University Program has

provided an interdisciplinary team approach to research and education in those areas necessary for fundamental advances at the forefront of aviation technology. This program provides results to the FAA from scientific and technology advances in air traffic management, atmospheric hazards, avionics, and human factors through research and development at three American universities. Also, the program is a source of talented engineers and scientists skilled in aviation-related fields.

## **101-130 Small Business Innovative Research (SBIR) Program**

**P**urpose: This program stimulates technological innovation, uses small business to meet federal research and development needs, increases private sector commercialization of innovations derived from federal research, and encourages participation by small disadvantaged companies in developing technological innovations. The SBIR program is congressionally mandated by the Small Business Research and Development Enhancement Act of 1992 (Public Law 102-504). The program is funded through project funds that reside in other R,E&D programs. By virtue of its FAA-wide scope, the SBIR program benefits the entire program spectrum that makes up the national air transportation system. The budgetary and technical resources can be applied to these programs in a timely and cost-effective manner. By enabling small, high technology companies to start up and prosper, the

SBIR contributes in a larger sense to the domestic economy and technology infrastructure.

**Approach:** Research topics are solicited from the various organizational elements throughout the agency. These topics then appear in an annual solicitation for proposals issued by the Department of Transportation. Individuals who submit the topics evaluate the proposals, and winners are chosen based on evaluations and agency needs. Firms selected to receive an award embark on the following three-phase process: Phase I – conduct feasibility-related experimental or theoretical research for R,E&D efforts up to \$100,000; Phase II – perform principal research effort (a performance period of approximately 2 years and funding up to \$750,000); and Phase III – perform commercialization of the research conducted under Phases I and II (no funding limit).

## **101-140 FAA/NASA Cooperative Programs**

**P**urpose: This program provides a synergistic and cost-effective R,E&D program with NASA in areas of mutual interest. The program enables the FAA to better respond to the goals and objectives of the FAA Strategic Plan through use of unique NASA facilities and other NASA resources. This cooperative effort provides substantial economic benefit and efficiency for the FAA's continuing research and development activity. FAA field offices have been established at NASA Ames and Langley Research Centers to coordinate, facilitate, and support joint research projects of mutual interest. In addition, these field offices propose new research projects and advise appropriate organizations in the FAA when new research areas of interest to the FAA are being considered by NASA. The field offices represent a unique FAA resource due to their proximity and access to NASA facilities, their knowledge of NASA personnel and ongoing

NASA research, and their understanding of FAA needs. Benefits realized through this cooperative relationship include an enhanced perspective on joint research activities, reduced duplication of similar efforts, and conservation of scarce funds and resources.

**Approach:** FAA/NASA cooperative activities are divided into broad areas of research defined by memoranda of understanding. Existing FAA/NASA research areas include: human factors, severe weather, cockpit/air traffic control integration, airworthiness, environmental compatibility, and program support. Specific cooperative activities are accomplished via memoranda of agreement relating to one or more research areas. Memoranda of agreement incorporate statements of work for specific research projects, establishing the objectives and responsibilities of each agency. Individual research

projects are negotiated to meet program-specific requirements, foster cooperative interaction, and share resources and unique facilities.

- Human factors research develops technology to improve the efficiency and safety of air and ground-based flight-related operations by reducing the consequences of human error.
- Severe weather research develops technology to improve aircraft operations safety in hazardous weather conditions.
- Cockpit/air traffic control integration research pursues aircraft/air traffic control related technologies and techniques to increase capacity and improve safety and efficiency of flight operations in the national airspace system.
- Airworthiness research develops technologies that support new aircraft development and certification and ensures the continued safe operation of existing aircraft.
- Environmental compatibility research develops technologies to reduce or eliminate noise and emission concerns in aircraft operations.
- Program support covers operation and maintenance of the FAA field offices located at NASA Ames and Langley Research Centers, including support of new, innovative individual and joint research projects and other broad interest FAA/NASA programs such as the Aviation Safety Reporting System (ASRS).

## **101-150 University Fellowship Research Program**

**P**urpose: This program expands the education and research activities associated with emerging concepts and technologies related to air traffic control, aviation safety, and security systems. A corollary purpose is to assist in attracting and recruiting qualified graduates to work for the FAA. The University Fellowship Research Program gives well-qualified and highly motivated graduate students an opportunity to conduct thesis research on FAA topics of interest while working with FAA engineers, scientists, and university professors. This program provides technology advancements to enhance the National Airspace System capability and im-

prove aircraft safety and security. Educational opportunities will be provided for talented engineers and scientists with the skills, interests, and abilities necessary to accomplish this work.

**Approach:** Participants in the program engage in formal course work at their respective universities and conduct research in FAA laboratories on FAA-directed topics. The program includes expanding universities' education and research activities in areas related to air traffic control systems and aircraft safety. Companion education and training activities are included to develop and enhance existing capabilities within the FAA.

## **101-160 Technology Transfer Program**

**P**urpose: This program promotes technology sharing among government, industry, and academia, and it transfers FAA R,E&D results into the mainstream of the United States economy. Technology transfer refers to the process by which existing knowledge, facilities, or capabilities developed under federal funding are used to fulfill public or private domestic needs. The United States is facing increasing challenges to its worldwide technical and economic primacy. A major problem in meeting these challenges is the extremely small return on the \$60 billion annual federal research and development investment. The central obstacle to increasing this return has been identified by Congress as the federal government's inability to transfer a significant portion of federally funded research and development results into the private sector for commercialization. Several key pieces of legislation have been enacted to overcome this obstacle.

The Stevenson-Wydler Technology Innovation Act of 1980 (Public Law 96-480) mandated that all federal laboratories assume technology transfer as a primary mission area. It provided the legal foundation for a technology transfer infrastructure within the federal laboratory system and established an Office of Research and Technology Applications at every federal R&D activity.

The Technology Transfer Act of 1986 (Public Law 99-502) established the formal tools and

mechanisms to accomplish technology transfer and mandated the following elements: (1) establish cooperative research and development agreements (CRDA) between federal and non-federal parties; (2) establish the Federal Laboratory Consortium, an affiliation of government laboratories to support the technology transfer mission; and (3) provide a cash incentive program to promote and encourage individual participation in meaningful technology transfer projects through awards and royalty sharing.

Executive Order 12591 of April 10, 1987, directed all federal laboratories to establish Technology Transfer Programs. In response to the laws and the Executive Order, the FAA developed Technology Transfer Order 9550.6 of October 30, 1989, which promulgates the FAA's Technology Transfer Program.

**Approach:** The FAA Technology Transfer Program goals are to: identify and promote intellectual property opportunities, expedite and facilitate technological innovation through the Innovation Development and Engineering Applications (IDEA) program, increase the return on the federal R&D investment, increase the Nation's base for technical knowledge and experience, translate technical developments into private sector applications, reward technical creativity, and comply with the letter and the spirit of federal technology transfer legislation.

## **101-170 Independent Research and Development (IR&D) Program**

**P**urpose: This program encourages contractors to perform independent research and development on topics relevant to the FAA's

long-term interests. This activity is a joint government/industry program legislated by Public Law 102-190.

The government recognizes IR&D as a necessary cost of doing business in a high technology environment and provides for cost recovery in the Federal Acquisition Regulations. Major contractors doing IR&D projects are requested to provide the FAA with information describing these projects. Descriptions also are submitted to the Defense Technical Information Center (DTIC) on a yearly basis in the prescribed format.

New IR&D legislation no longer requires yearly on-site review evaluations, but encourages IR&D technical interchange meetings. These meetings are arranged by mutual agreement between the contractor and government to review and discuss a focused set of technology and/or product development projects. The purpose of these meetings is to: promote face-to-face detailed technical interaction between the contractors and the government; provide opportunities for government presentations on relevant technical needs and activities; and provide opportunities for government participants to visit the contractor's facilities and operations.

The IR&D program's benefits are:

- Access to industry views about technical and business directions for the future.

- A broader range of technical options in an R&D project's early phases.
- An available pool of qualified contractors who can respond competently and competitively to government requirements.
- Spreading the risk and cost of encouraging new ideas and concepts.
- An enhanced capability for continuous innovation to meet technical challenges for the future.

**Approach:** The Office of Research and Technology Applications has access to the DTIC proprietary IR&D data base. During the year, customized data base searches are performed for the R,E&D services. Upon request, the IR&D program office will arrange technical interchange group meetings to explore any company's IR&D projects. Further contacts may then be made with the principal investigators to monitor the research results and their potential use to the FAA.

## **101-180 Aviation Research Grant Program**

**P**urpose: This program provides the FAA with the ability to support and access innovative, advanced research to support the FAA mission of improving aviation safety, security, capacity, and the environment, resulting in a safer and more efficient air transportation system. This goal is accomplished by awarding aviation research grants or cooperative agreements to colleges, universities, and nonprofit research institutions to perform long-term research of potential benefit to the aviation industry. In the case of

Aviation Security, grants may be issued to for-profit research organizations. This program also allows the FAA to greatly increase the aviation research talent base available to the FAA and the aviation community, a valuable resource necessary to achieve the vision for the aviation system of the future.

**Legislation:** FAA R,E&D Reauthorization Act  
Title IX, Public Law 101-508 Aviation Security Improvement Act, Public Law 101-604

Collectively, the legislation directs that:

- Authority be given to the FAA to award single- and multi-year research grants or cooperative agreements to colleges, universities, and other research institutions
- Research topics shall include, but not be limited to, ATC automation; aviation applications of artificial intelligence; aviation and air traffic control simulation and training technologies; human factors; airport and air-space planning and design; airport capacity enhancement; aviation security; and aircraft safety.
- At least 3 percent of the total FAA R,E&D budget be devoted to fund the research grant program.
- The FAA shall contribute to building an aviation research talent base of technical professionals trained in the sciences, engineering, and mathematics, and mechanics related to aeronautics and aviation.

**Approach:** Program execution is guided by a set of established laws, regulations, policies, and internal and external procedures which are

updated continuously. A process for advertising, soliciting, and evaluating research proposals was developed, initiated, and is continually measured to assure the process is effective and efficient. This process, and the process for awarding, administering, and closing out grants, is detailed in FAA Directive 9550.7, Aviation Research Grants. A database has been established to ensure that proposals and grant awards are properly tracked with key events monitored. The solicitation is available electronically on the FAA Technical Center World Wide Web server at URL <http://www.tc.faa.gov> or anonymous FTP at <ftp://tc.faa.gov>. Movement is towards a totally electronic process for grants administration, including award. A network of proposal technical evaluators and grant technical monitors has been established.

One hundred forty-five grant awards have been made since program inception. These grants are funded through individual FAA program support. Program funded grants are supported through the budgeted funds of the technical programs and support research responsive to the needs of a specific R,E&D program. The Aviation Research Grant Program assists the R,E&D program offices in achieving their goals.

## APPENDIX B

### **Research, Engineering and Development (R,E&D) Management, Plan, Control, and Support**

A process was initiated in 1990 to provide more in-depth analysis and control for R,E&D activities. The process emphasizes developing a systems engineering approach to define, implement, and manage the research required for National Airspace System (NAS) development. This process' maintenance and enhancement is critical to the R,E&D program efficiency and effectiveness. Supporting the R,E&D infrastructure contributes to virtually every project within the R,E&D environment.

The R,E&D infrastructure provides the vehicle to ensure that the total R,E&D program is conducted as a cohesive, integrated entity and permits evaluating progress across the thrust areas. This is critical due to the integrated nature, both technical and fiscal, of the individual R,E&D projects with each other, with the future aviation system, and with the Aviation System Capital Investment Plan.

R,E&D resources are required for the following efforts:

#### **Research, Engineering and Development Plan**

The Plan for Research, Engineering and Development is published in response to Section 44501 of Title 49, United States Code (Transportation). The Plan is published annually and describes the research, engineering, and development projects the FAA Administrator considers necessary to carry out the FAA's mission.

#### **R,E&D Management, Plan, and Control**

The R,E&D management and control process and automated support system will be maintained, refined, and further integrated into the R,E&D planning and budgetary processes. Specific products will include publishing the annual R,E&D Plan, associated report to Congress on R,E&D accomplishments from the previous year, and technical/engineering schedule support for the R,E&D program.

#### **R,E&D Advisory Committee**

The committee will provide the agency with reports, advice, and recommendations regarding the needs, objective, plans, approaches, contents, and accomplishments with respect to the aviation research program. The committee considers aviation research needs to support the FAA mission and addresses such areas as airport capacity, system safety, aircraft safety, aeromedical research, aviation security, and future ATC technology.

#### **R,E&D Program Support**

Provides for in-house support for system engineering and development, international requirements, and NAS program analysis activities.

#### **Technical Laboratory Facility**

The FAA Technical Center operates and maintains laboratory facilities to perform test, evaluation, and integration efforts. Funding is required for maintenance, software licensing fees, support costs, and other costs associated with operating the technical laboratories.

## Federally Funded Research and Development Center

The Federally Funded Research and Development Center (FFRDC) provides the FAA with a long-term essential research, development, and engineering resource offering an extensive corporate knowledge base and high-quality expertise. The FFRDC organization operates in the

public trust with access to sensitive or proprietary data, providing a quick-response capability for conflict free, objective, independent analyses. The FFRDC offers the detailed research necessary to meet the FAA's needs for new technology in the area of air traffic management, including new developments in traffic flow management, navigation, separation assurance, and surveillance technology.

## APPENDIX C

### List of Acronyms and Abbreviations

#### A

AAIT	Air Accident Investigation Tool
AAS	Advanced Automation System
AC	Advisory Circular
ADL	Aeronautical Data Link
ADR	Automated Demand Resolution
ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance Broadcast
AEEC	Aeronautical Electronics Engineering Committee
AERA	Automated En Route Air Traffic Control
AIDC	Air Traffic Services Interfacility Data Communication
AF	Airway Facilities
AGATE	Advanced General Aviation Transport Experiments
AGFS	Aviation Gridded Forecast System
AIDC	Air Traffic Services Interfacility Data Communications
AMASS	Airport Movement Area Safety System
AMSS	Aeronautical Mobile Satellite Services
AOAS	Advanced Oceanic Automation System
AOC	Airline Operations Center
APMS	Automated Performance Measurement System
AQP	Advanced Qualification Program
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Terminal System
ASDE	Airport Surface Detection Equipment
ASI	Aviation Safety Inspector
ASR	Airport Surveillance Radar
ASRS	Aviation Safety Reporting System
ASTA	Airport Surface Traffic Automation
ATC	Air Traffic Control
ATCSCC	Air Traffic Control System Command Center
ATIS	Automated Terminal Information Service
ATM	Air Traffic Management

ATMS	Advanced Traffic Management System
ATN	Aeronautical Telecommunications Network
AWDL	Aviation Weather Development Laboratory

## C

CASA	Controller Automation Spacing Aid
CAT	Category and Computer Assisted Tomography
CDTI	Cockpit Display of Surface Traffic Information
CHI	Computer/Human Interface
CIP	Capital Investment Plan
CNS	Communications, Navigation, and Surveillance
CNS/A	Communications, Navigation, and Surveillance Avionics
CRDA	Cooperative Research and Development Agreement or Converging Runway Display Aid
C/SOIT	Communications/Surveillance Operational Implementation Team
CTAS	Center-TRACON Automation System

## D

DA	Descent Advisor
DGPS	Differential corrected Global Positioning System
DME	Distance Measuring Equipment
DOD	U.S. Department of Defense
DOTS	Dynamic Ocean Track System
DSV	Digital Systems Validation
DTIC	Defense Technical Information Center

## E

EDP	Expedite Departure Path
EDPRT	Expert Diagnostic, Predictive, and Resolution Tools
EFF	Experimental Forecast Facility
ETMS	Enhanced Traffic Management System
EWR	ICAO Designator for Newark Airport

## F

F&E	Facilities and Equipment
FAA	Federal Aviation Administration
FANS	Future Air Navigation System

FAR	Federal Aviation Regulations
FAST	Final Approach Spacing Tool
FBL	Fly-By-Light
FBW	Fly-By-Wire
FDPR	Flight Data Processor Replacement
FIS	Flight Information Services
FLOWSIM	Flow Simulation Model
FMS	Flight Management System
FSM	Flight Schedule Monitor

## **G**

GA	General Aviation
GPS	Global Positioning System
GPRA	Government Performance and Results Act

## **H**

HARS	High Altitude Route System
HF	High Frequency
HIRF	High Intensity Radiated Fields
HSCT	High-Speed Civil Transport
HSI	Human Systems Integration
HUMS	Health and Usage Monitoring Systems

## **I**

ICAO	International Civil Aviation Organization
ICAP	Integrated Crashworthiness Analysis Program
ICTS	Icing Induced Tailplane Stalls
IDEA	Innovation Development and Engineering Applications
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
IR&D	Independent Research and Development
ISO	International Standards of Organization
ITS	Intelligent Tutoring System
ITWS	Integrated Terminal Weather System

**J**

JAA	Joint Airworthiness Authority
JFK	ICAO designator for John F. Kennedy International Airport
JTA	Job Task Analysis

**K**

KRASH	A software package for airframe structural analysis
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**L**

LAAS	Local Area Augmentation System
LGA	ICAO designator for LaGuardia Airport
LIP	Limited Installation Program

**M**

Mode S	Mode Select Discrete Addressable Secondary Radar System with Data Link
MOPS	Minimum Operational Performance Standards

**N**

NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NASPAC	National Airspace System Performance Analysis Capability
NDI	Nondestructive Inspection
NEXRAD	Next Generation Weather Radar
NOAA	National Oceanic and Atmospheric Administration
NSC	National Simulation Capability

**O**

OAK	ICAO designator for Oakland International Airport
OBIGGS	Onboard Inert Gas Generating System
OCC	Operations Control Center
ODID	Operational Display and Input Development
ODL	Oceanic Data Link
OPTIFLOW	Optimized Flow Planning Tool
OSDS	Oceanic System Development and Support
OSI	Open Systems Interface
OT&E	Operational Test and Evaluation

**P**

PC	Personal computer
PLV	Powered-lift Vehicle
PRM	Precision Runway Monitor

**R**

RADS	Risk Analysis Decision Support
RAMS	Reorganized Mathematical Air Traffic Control Simulator
R,E&D	Research, Engineering and Development
RFP	Request for Proposal
RNP	Required Navigation Performance
R-SDAT	Regional Airspace Sector Design Analysis Tool
RTCA	Radio Technical Commission for Aeronautics

**S**

SARP's	Standards and Recommended Practices
SATCOM	Satellite Communications
SATORI	Systematic Air Traffic Operations Research Initiative
SBIR	Small Business Innovation Research
SDAT	Sector Design Analysis Tool
SDTF	SMA Development and Test Facility
SE	Strategy Evaluation
SFA	Survey Feedback Action
SFO	ICAO designator for San Francisco International Airport
SIMC	Surveillance Infrastructure Management Concepts
SIMMOD	A trademark name for the FAA's Airport and Airspace Simulation Model
SJC	ICAO designator for San Jose International Airport
SMA	Surface Movement Advisor
SMARTFLO	Knowledge-based Flow Planning Tool
SPAS	Safety Performance Analysis System
SPEARS	Screener Proficiency Evaluation And Reporting System

**T**

TATCA	Terminal Air Traffic Control Automation
TCA	Transport Canada
TCAS	Traffic Alert and Collision Avoidance System
TCCC	Tower Control Computer Complex

TERPS	Terminal Instrument Procedures
TFM	Traffic Flow Management
TMA	Traffic Management Advisor
TRACON	Terminal Radar Approach Control
TRB	Transportation Research Board
T-SDAT	Terminal Airspace Sector Design Analysis Tool
TSO	Technical Standard Order

## **U**

U.S.	United States
USWRP	United States Weather Research Program

## **V**

VHF	Very High Frequency
VLCT	Very Large Commercial Transports
VOR	VHF Omnidirectional Range

## **W**

WAAS	Wide Area Augmentation System
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## APPENDIX D

### Alphabetical Index of R,E&D Projects

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## APPENDIX E

### Project Changes Since The 1991 R,E&D Plan

Projects that have been completed, renamed, combined, or withdrawn since the 1991 R,E&D Plan publication are listed by chapters.

PROJECT NUMBER	PROJECT TITLE	LAST ACTIVITY
021-110	<b>Capacity and Air Traffic Management Technology</b> Advanced Traffic Management System sections pertaining to Dynamic Ocean Track System (DOTS)	Combined With Project 021-140 1992
	Advanced Traffic Management System to Advanced Traffic Management System (ATMS)/Operational Traffic Flow Planning (OTFP)	Name Change 1995
	Advanced Traffic Management System (ATMS)/Operational Traffic Flow Planning (OTFP) to Advanced Traffic Management System	Name Change 1996
021-140	Oceanic ATC Automation to Oceanic Air Traffic Automation	Name Change 1992
021-150	ATC Applications of Automatic Dependent Surveillance (ADS)	Combined With Project 021-140 1992
021-160	ATC Automation Bridge	Terminated in 1993
021-170	Advanced Automated En Route ATC (AERA) Concepts	Withdrawn in 1992
021-180	Terminal ATC Automation (TATCA)	Transferred to F&E 1996
021-190	Airport Surface Traffic Automation (ASTA)	Transferred to F&E 1996

PROJECT NUMBER	PROJECT TITLE	LAST ACTIVITY
021-200	Surface Movement Safety and Guidance  Surface Movement Safety and Guidance to Surface Movement Advisor (SMA)  Surface Movement Advisor (SMA)	Combined With Project 021-190 1992  Name Change 1996  Removed From Project 021-190 1996
021-210	Tower Interim Display System to Tower Integrated Display System  Tower Integrated Display System (TIDS)	Name Change 1992  Withdrawn in 1996
021-220	Airport Capacity Improvements to Multiple Runway Procedures Development	Name Change 1993
021-230	Wake-Vortex Avoidance/Advisory System to Wake-Vortex Separation Standards Reduction  Wake-Vortex Separation Standards Reduction to Wake-Vortex Separation Standards	Name Change 1992  Name Change 1995
022-140	Vertical Flight Program to General Aviation and Vertical Flight Technology Program  General Aviation and Vertical Flight Technology Program to General Aviation and Vertical Flight Program	Name Change 1995  Name Change 1996
025-110	National Simulation Laboratory (NSL) to National Simulation Capability (NSC)	Name Change 1992
025-120	Operational Traffic Flow Planning	Combined With Project 021-110 1995
025-140	System Performance and Investment Analysis	Moved From Appendix B 1995
026-120	Diagnostic Tools and Future Technology to Airway Facilities Future Technologies	Name Change 1993 Combined With 026-110 1994 Withdrawn in 1996

PROJECT NUMBER	PROJECT TITLE	LAST ACTIVITY
026-130	Functional Models and Evaluation Tools to Airway Facilities Functional Models and Evaluation Tools	Name Change 1993 Combined With 026-110 1994
027-110	Automation System Assessment	New Project 1996
	<b>Communications, Navigation, and Surveillance</b>	
033-110	Terminal Area Surveillance System (TASS)	Withdrawn in 1996
033-120	Mode S Sensor Data Link Enhancement	Withdrawn in 1993
	<b>Weather</b>	
041-120	Airborne Meteorological Sensors	Combined With Project 041-110 1996
042-110	Integrated Airborne Windshear to Aeronautical Hazards Research	Name Change 1995
	<b>Airport Technology</b>	
051-140	Demonstrations and Concepts Evaluation	Withdrawn in 1993
	<b>Aircraft Safety Technology</b>	
062-110	Aircraft Crashworthiness/Structural Airworthiness to Advanced Materials/Structural Safety	Name Change 1995
064-110	Flight Safety/Atmospheric Hazards Research to Flight Safety/ Atmospheric Hazards	Name Change 1992
064-120	International Aircraft Operator Information System	Terminated in 1993
069-110	Cabin Safety	New Project 1996

PROJECT NUMBER	PROJECT TITLE	LAST ACTIVITY
072-110	<b>System Security Technology</b> Weapons Detection	Combined with project 071-110 1994
073-110	Airport Security to NAS Security	Name Change 1994
	NAS Security to Airport Security Technology Integration	Name Change 1996
074-110	Security Systems Integration	Combined with project 071-110 1994
	<b>Human Factors and Aviation Medicine</b>	
083-110	Airway Facilities Maintenance Human Factors to Airway Facilities Human Factors	Name Change 1992
087-110	Workforce Performance Optimization	New Project 1994 Withdrawn in 1996
	<b>Environment and Energy</b>	



## 1996 Research, Engineering, and Development Plan Feedback

List below any suggestions on how you feel we might improve the Research, Engineering, and Development Plan (attach an extra sheet if necessary):

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